Hekimian

41-01

MICROFILM

OPERATING MANUAL

MODEL 41-01

TRANSMISSION TEST SET

HEKIMIAN LABORATORIES, INC.

15825 SHADY GROVE ROAD

ROCKVILLE, MARYLAND 20850 USA

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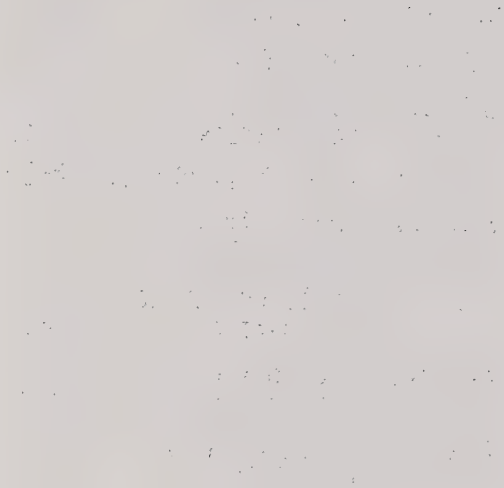

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SECTION 1.0

INTRODUCTION

1.1 GENERAL

The Model 41 Transmission Test Set combines the functions of noise, level, and frequency measurements with a flexible signal generator in a compact rack-mounted instrument designed to fill a variety of fixed plant requirements. Small enough to be added to existing bays and inexpensive enough to replace or augment congested centralized test facilities, it sets a high level of reliability, accuracy, and operating convenience.

Dual digital displays simultaneously present fully auto-ranged noise/level measurements with frequency readings from 40 Hz to 20 kHz. Indicating pushbutton controls are arranged for ease of operation and all variable controls have excellent resolution and setability. Independent selection of receive and send impedances, and an audio monitor add to the unit's flexibility.

Level measurements are made directly in dBm using an average-type detector in compliance with Bell System Standards.

Noise measurements are made directly in dBrn using a quasi-rms detector. C-message and 3 kHz flat weighting filters are front panel selected along with a 990 to 1030 Hz notch filter which meets the revised (1975) Bell System Standards.

Frequency is measured on the second display and provides a dual-range four-digit readout in kHz with 1 or 10 Hz resolution.

The flexible signal generator features continuous and stepped frequency coverage. For noise measurements, both a low distortion, crystal-controlled 1004 Hz holding tone and a quiet termination are provided. To achieve high resolution and setability, the frequency and level controls are true 10 turn instrument potentiometers.

An audio monitor is provided to monitor the signal being measured.

The Model 41 is a rugged, compact instrument designed for rack-mounted applications in a central office. The unit is powered by a self-contained power supply which draws 15 watts from either the commercial ac power line or a -24 V dc station battery. The test set is optionally available for a -48 V dc station battery. The power cord and fuse are located on the rear panel of the instrument.

1.2 SPECIFICATIONS

The electrical and mechanical specifications for the Model 41 are listed in Table 1-1.

A photograph of the Model 41 is shown in Figure 1-1.

TABLE 1-1
SPECIFICATIONS

GENERAL	
Measurements	Level (dBm), noise (dBrn). frequency (kHz)
Displays	Dual display, noise or level, and frequency
Generator	Sine wave, fixed and variable frequency, variable level

INPUT

Impedance	600 Ω, 900 Ω, or bridged
Return Loss	>30 dB, 200 Hz to 20 kHz
Balance	>60 dB, up to 4 kHz
Line Holding	Resistive termination, 3 Watts maximum

LEVEL MEASUREMENT

Frequency Range	40 Hz to 20 kHz
Measurement Range	-80.0 dBm to +10.0 dBm, full auto-ranging
Accuracy	dBm

dBm	40 Hz	100 Hz	4 kHz	20 kHz
+10 to -40	±0.5	±0.2 dB*	±0.5	
-40 to -70	±1.0	±1.0 dB	±1.0	

*±0.1 dB at 1000 Hz for levels between 0 and -19 dBm

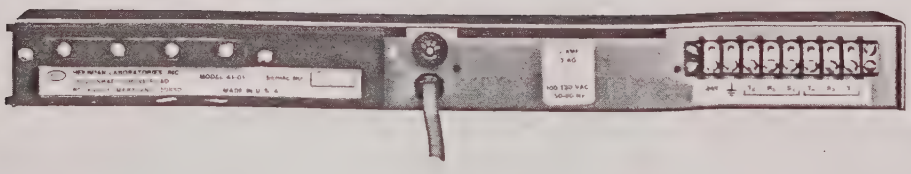
Detector Type	Average

NOISE MEASUREMENT

Weighting Filters (Ref. Bell PUB 41009)	C-Message 3 kHz Flat Holding tone notch filter (995 to 1025 Hz)
Measurement Range	+10 dBrn to +100 dBrn
Accuracy	±1 dB, +20 dBrn to +100 dBrn
Detector Type	Quasi-rms

FREQUENCY MEASUREMENT	
Frequency Range	40 Hz to 20 kHz
Level Range	-40 dBm to +10 dBm
Resolution/Update	1 Hz/2 times per second 10 Hz/10 times per second
Accuracy	±1 Count
GENERATOR	
Frequency Range	200 Hz to 20 Hz
Modes	Continuous 100.4 Hz step 1004 Hz OFF (Quiet termination)
Level Range	-40 dBm to +10 dBm, continuously adjustable
Distortion	>60 dB, 1004 Hz fixed >50 dB, 200 Hz to 4000 Hz >40 dB, 4000 Hz to 20 kHz
Impedance	600 Ω, 900 Ω, balanced
Return Loss	>30 dB, 200 Hz to 4000 Hz
CONNECTORS	
Front Panel	5-way binding posts, 310 jack
Rear Panel	Screw-type barrier strip
POWER	100-130 V ac, 47-63 Hz, 15 watts or -24 V dc @ 600 mA
MECHANICAL	19" (48.25 cm) W x 1-3/4" (4.45 cm) H x 12" (22.86 cm) D Rear-mounted input/output barrier strip
OPTIONS	-1. 110/220 V ac operation -11. -48 V dc operation -12. Optional input connectors -14. 100.0 Hz step in place of 100.4 Hz.

FRONT VIEW



REAR VIEW

FIGURE 1-1 MODEL 41 TRANSMISSION TEST SET

SECTION 2.0

INSTALLATION

2.1 GENERAL

The Model 41 Transmission Test Set is designed for ease of operation and installation. After the unit has been removed from its shipping container, perform a complete visual inspection for possible damage. If damage is found, notify the carrier immediately; do not destroy any packing material until an agent of the carrier has examined it. Under U.S. shipping regulations, damage claims must be collected by the consignee; do not return the instrument to Hekimian Laboratories, Inc., until a claim for damages has been established.

To inspect the unit's interior, remove the screws along the sides of the unit. These hold the top cover which may then be removed and complete visual inspection performed.

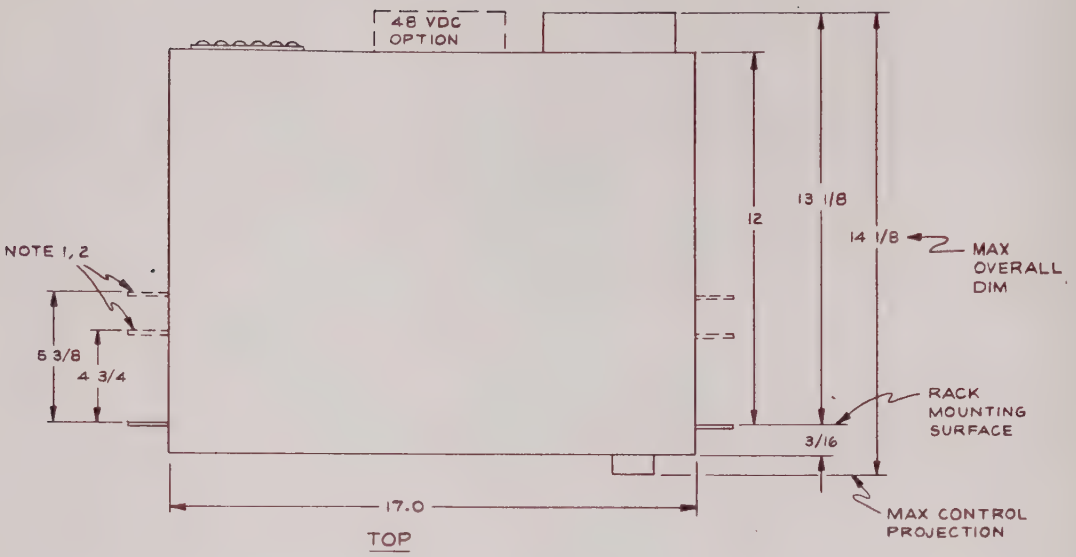
All internal adjustments have been set at the factory and no further adjustments are required prior to installation or use of the equipment.

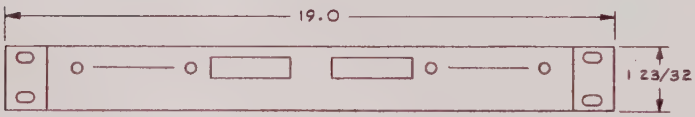
2.2 INSTALLATION

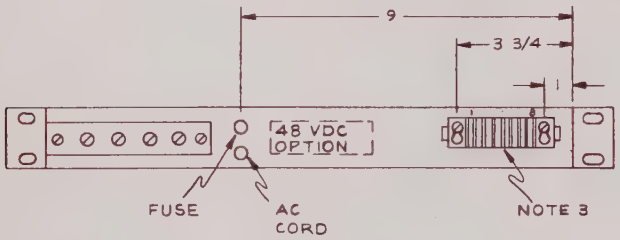
Power for the unit is supplied either from the ac power line via the line cord or from a -24 V dc station battery through the rear panel barrier strip. The line cord should be disconnected when the unit is operated on station battery. Check power supply polarity carefully. A reverse polarity may cause severe damage to the Model 41 power supply. The positive terminal of the -24 V input is connected to the chassis. Use only a floating 24 V supply or a positive ground supply.

Signal Receive/Send lines are connected to the front-panel Western Electric 310 jacks, 5-way binding posts, or the rear-panel barrier strip. Shielded cable is recommended for all signal connections. Ground connections for terminating cable shields are provided on the barrier strip.

Figure 2-1 shows overall mounting and dimensional data for the Model 41. Alternate mounting locations of the rack-adapter ears are shown and may also be used for the 21" and 23" optional rack adapters. When rack mounting is not desired, the ears may be completely removed.







NOTES:

1. RACK MOUNTING EARS ARE DETACHABLE. MAY BE REMOUNTED IN LOCATIONS SHOWN.
2. RACK MOUNTING EARS AVAILABLE FOR 23" RACKS, AND 1 3/4" OR 1" RACK HEIGHT INCREMENTS.
3. REAR BARRIER STRIP CONNECTIONS:

TERM	FUNCTION
1	DC STATION BATTERY (-)
2	DC STATION BATTERY (GND)
3	GND
4	SEND-OUTPUT
5	SEND-OUTPUT
6	GND
7	RECEIVER-INPUT
8	RECEIVER-INPUT

4. DWG COVERS SERIAL NUMBERS 001 THRU 199.
5. ALL DIMENSIONS ARE IN INCHES.

FIGURE 2-1 MODEL 41 INSTALLATION DIMENSIONS

SECTION 3.0

OPERATION

3.1 GENERAL

This section contains a description of the controls and indicators, operation procedures, and methods of measurement to be used with the Model 41. Prior to operation, be sure that all connections to the instrument are made in accordance with instructions in Section 2.0.

The Model 41 Block Diagram is shown in Figure 3-1. Signal flow is from left to right. The generator section consists of a crystal-controlled spectrally-pure 1004 Hz test tone and a continuously-variable voltage-controlled oscillator which may be frequency locked at 100 Hz intervals. The desired mode of operation is selected by the front-panel pushbutton switches. The desired signal is then fed to the send amplifier whose amplitude is controlled by the front-panel generator level control.

The receiver can be selected to measure either level or noise, with or without holding tone. When a desired mode has been selected, the signal is then fed to the auto-range amplifier, detectors and digital voltmeter. Connections are also made to the frequency counter and audio monitor amplifier.

The master clock consists of a crystal-controlled 2 MHz oscillator from which all other timing pulses are derived. This oscillator is also used to derive the fixed 1004 Hz test tone.

3.2 CONTROLS AND INDICATORS

The controls and indicators used in operation of the Model 41 are described in Table 3-1. All controls are located

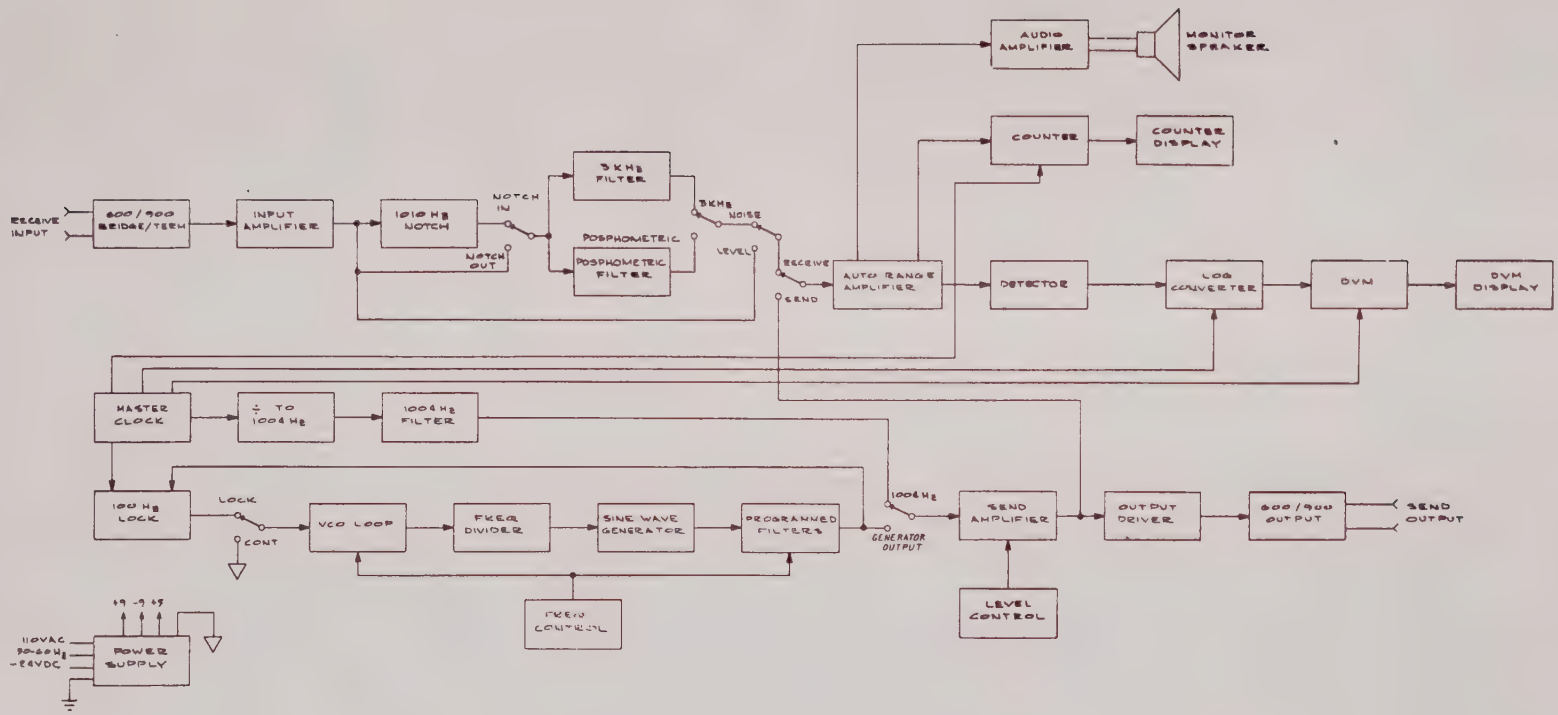


FIGURE 3-1 MODEL 41 BLOCK DIAGRAM

on the front panel and are shown in Figure 1-1. No internal adjustments are required during normal operation.

TABLE 3-1

CONTROLS AND INDICATORS

DESIGNATION	FUNCTION
RECEIVE Pushbutton Switches	Selects either 600 Ω or 900 Ω impedance, terminated or bridged modes and sets the dBm reference impedance for the input.
DISPLAYS Pushbutton Switches	Selects either the receive or send signals to be monitored and displayed on the level meter and frequency counter.
DBRN Pushbutton Switches	Selects either the C-Message or 3 kHz flat weighting filters with or without the notch filter. When either of the noise weighting filters is selected, a quasi-rms detector is used and the level meter displays dBrn directly.
DBM Pushbutton Switches	Selects the average detector used for flat response and level measurements and causes the level meter to display level directly in dBm.
KHZ Pushbutton Switches	Selects either the fast or slow update mode of the frequency counter and allows the display to be blanked during noise measurement.
GENERATOR Pushbutton Switches	Selects the desired generator mode.
FREQ Control	Selects the desired frequency in continuous or 100 Hz locked mode of operation.

LEVEL Control	Sets the desired output level.
SEND Pushbutton Switches	Selects either 600 Ω or 900 Ω impedance and sets the dBm reference for the generator.
POWER Pushbutton Switch	Controls the ac primary power to the instrument.
MONITOR Control	Controls the level of the monitor speaker.

3.3 OPERATING ADJUSTMENTS

This section presents the operational adjustment used with the Model 41. Connections to the send and receive terminals should be made in accordance with instructions given in Section 2.0

3.3.1 RECEIVE MEASUREMENTS

This section contains the detailed operational instructions to be used for the level meter. To monitor and display the input signal, depress the display button marked REC.

3.3.1.1 RECEIVE INPUT IMPEDANCE

Select the receiver reference impedance by depressing either the 600 Ω or 900 Ω pushbutton. Select either the terminated or bridged mode by depressing either the TERM or BRIDGE pushbutton.

3.3.1.2 LEVEL MEASUREMENT

When the receive input impedance has been properly selected, depress the DBM pushbutton switch. This selects the average detector and indicates level directly in dBm referenced to the selected receive input inpedance.

The range of level measurement is -80.0 to +10.0 dBm. When the input is above or below this range, the display numbers will go blank leaving an illuminated + sign when the input is above +10 dBm or a - sign when it is below -80 dBm.

3.3.1.3 NOISE MEASUREMENTS

Message circuit noise is measured by depressing either the C-MSG or 3 KHZ FLAT pushbutton. The NOTCH pushbutton may be depressed if a 995 Hz to 1025 Hz holding tone is being used for noise with tone measurement. All noise measurements are read out directly in dBrn.

The range of noise measurements is +10 to +100 dBrn. When the input is above or below this range, the display numbers will go blank leaving an illuminated + sign when the input is above +100 dBrn or a - sign when it is below +10 dBrn.

3.3.2 DISPLAY SELECTION

Either the send or receive signal level and frequency may be measured by depressing the proper DISPLAYS pushbutton. The display pushbuttons select the input to the level meter, frequency counter, and audio monitor. In the SEND mode, the noise weighting filters are bypassed so only an absolute send level reading is displayed.

3.3.3 FREQUENCY MEASUREMENT

The input to the frequency counter is controlled by the DISPLAYS pushbutton. Frequency resolution and update rate are controlled by the KHZ FAST and SLOW pushbuttons. In the 1 Hz mode, the resolution is 1 Hz and the update rate is 2 per second. In the 10 Hz mode, the resolution is 10 Hz and the update rate is 10 per second.

In the 1 Hz mode, frequencies from 40 Hz to 9.999 kHz may be measured. Frequencies above 9.999 kHz will cause the display to flash, indicating an overrange condition. The 10 Hz mode measures frequency from 40 Hz to above 20 kHz. If the frequency display is all zeros when the FAST or SLOW mode has been selected, the receive input level is below approximately -45 dBm.

The KHZ OFF pushbutton is provided so that the display may be blanked if desired during noise measurement.

3.3.4 AUDIO MONITOR

Input to the audio monitor is controlled by the DISPLAYS pushbuttons. The level of the audio monitor is controlled by the front panel MONITOR control.

3.3.5 GENERATOR

This section contains the detailed operational instructions to be used for the Model 41 Generator. To measure the generator frequency and level, depress the display pushbutton marked SEND. Select the desired output impedance by depressing either the 600 Ω or 900 Ω SEND pushbuttons.

3.3.5.1 CONTINUOUS MODE

Depress the generator pushbutton marked CONT. Use the FREQ and LEVEL controls to adjust for the proper output as indicated on the Model 41 displays.

3.3.5.2 100.4 HZ STEP

Depress the generator pushbutton marked STEP. The FREQ control will now adjust the output frequency in 100.4 Hz steps. With the 100.0 Hz step option the output frequency varies in 100 Hz steps.

3.3.5.3 1004 Hz FIXED FREQUENCY MODE

Depress the generator pushbutton marked 1004 HZ. This selects the crystal-controlled spectrally-pure 1004 Hz test tone. Output level is adjusted using the LEVEL control.

3.3.5.4 SEND LEVEL MEASUREMENTS

In accordance with telephone company transmission level measurement practices, the SEND level measurement is calibrated in terms of the level that will exist at the SEND terminals when they are properly terminated in the impedance selected by the SEND pushbutton switches. If the actual terminating impedance is different than the selected impedance

(600 Ω or 900 Ω), send levels other than that indicated will exist at the SEND terminals. The actual level across the SEND terminals may be verified using an external meter or temporarily bridging the Model 41 receive input (in the BRIDGE mode) across the SEND terminals. The receive impedance should be the same as the send impedance.

3.3.6 REAR-PANEL CONNECTIONS

The rear-panel mounted terminal block is provided for connection of input leads, output leads and 24 V station battery. The positive terminal of the 24 V input is connected to the chassis. Use only a floating 24 V supply or a positive ground supply. A reverse polarity may cause damage to the Model 41.

When the 24 V station battery is being used, the ac line cord should be disconnected.

SECTION 4.0

THEORY OF OPERATION

4.1 GENERAL

This section provides a general theory of operation followed by detailed circuit operation on a functional block basis. The Model 41 is entirely solid state and makes extensive use of integrated circuit operational amplifiers and CMOS digital logic circuits. Discussions of conventional transistor circuitry, operational amplifier theory and digital logic circuitry are available in a number of current reference texts. The Model 41 Block Diagram shown in Figure 3-1 is discussed in the following sections.

4.1.1 LEVEL-NOISE METER

The input circuitry bridges or terminates 600 and 900 Ω receive lines. This input signal is then transformer-coupled to the input amplifier which is directly connected to the auto-ranging circuitry for level measurements and drives the 1010 Hz Notch and C-Message/3 kHz weighting filters for noise measurements. The auto-range circuitry, which may monitor either the receive or send signals, automatically adjusts the amplifier gain to keep the received signal level within the range of the noise and level detectors. The dc output of the selected detector is applied to the log converter. The log converter changes the linear voltage output of the detectors to a logarithmic output to allow a display of the level and noise directly in dB. The digital voltmeter takes the output of the log converter and control signals from the auto-range amplifier and converts these to the 3-digit digital display of noise and level.

A front-panel controlled monitor speaker is also provided which allows the operator to audibly monitor the input signal.

4.1.2 FREQUENCY COUNTER

A 4-digit frequency counter with selectable 1 Hz or 10 Hz resolution monitors the signal applied to the level-noise meter. The counter uses a large scale integration (LSI) CMOS IC to perform the frequency counting operation and drive the 4-digit multiplexed display.

4.1.3 GENERATOR AND CLOCK

The tuneable frequency generator uses a voltage-controlled oscillator (VCO) operating at 40 times the output frequency to drive a low distortion stairstep sine wave generator. The generator output is processed by four programmed filters to provide excellent spectral purity. Continuous frequency control or locked 100.4 Hz (100.0 Hz) steps using frequency lock circuitry in the VCO may be front-panel selected.

A separate fixed frequency divider and 2-pole 1004 Hz band-pass filter generates a high stability, high purity 1004 Hz holding tone.

The selected generator signal is applied to the send amplifier where the output level is controlled and then to the output driver which transformer couples the selected generator signal at either a 600 Ω or 900 Ω impedance level to the send terminals.

A 2 MHz master clock oscillator is used to generate the various clock, control, updating and locking frequencies required in the operation of the noise-level meter, frequency counter and generator sections. The master clock is crystal-controlled.

4.1.4 POWER SUPPLY

The power supply provides the ±9 V and +5 V used in the Model 41. The supply is designed to operate directly from a -24 V external dc source or from the 115 V ac line using a transformer and bridge rectifier to supply an internal 24 V dc. All voltages are electronically regulated for accuracy and long-term stability with temperature and line voltage fluctuations.

4.2 DETAILED CIRCUIT OPERATION

The following sections describe the detailed circuit operations for the level-noise meter, frequency counter, generator and clock and power supply. Schematics and timing diagrams are presented in Section 5.0.

4.2.1 LEVEL-NOISE METER

4.2.1.1 INPUT CIRCUIT

The input signal is connected to the front-panel Western Electric 310 jack or 5-way binding posts. It is then routed to the 41-400 board which contains the dc isolation capacitors C1, C2, the TERM switch S3, and the 600/900 Ω terminating resistors and selection switches. The signal is then routed through interconnecting cable FC1 to the 41-100 board where it is transformer-coupled to the input amplifier IC1. This wide-band low-noise unity gain op/amp drives the level and noise filter circuitry.

4.2.1.2 NOISE FILTERS

The input amplifier IC1 drives the 4-pole notch filter IC5, IC6, IC7, and IC8. This filter makes use of 4 active notch filters with leapfrog feedback for overall stability. The notch design has a pass-band loss of approximately 6 dB and each pole is provided with individual frequency and depth adjustments.

The 3 kHz flat filter IC2A and C-Message filter IC2B, IC3, and IC4 use conventional active filter techniques to generate these noise weighting characteristics.

The input amplifier and notch filter outputs and the 3 kHz and C-Message inputs/outputs are routed to the 41-400 board where the notch in/out is selected by the NOTCH switch S7 and isolated by amplifier IC1. The input signal with or without the notch is connected to the weighting filters whose output are selected by the C-MSG and 3 kHz FLAT switches S8 and S9.

4.2.1.3 LEVEL MEASUREMENT

The LEVEL switch S10A of PCB 41-400 selects either the noise signal or level signal for routing to the FET gate Q1 on the 41-100 board. The send signal is connected to FET gates Q3, Q22 which provide both a transmission gate and short to ground to minimize send signal crosstalk.

The 600 Ω and 900 Ω gain adjustment is controlled by switches S1, S6, and S18. The control signal is fed to the FET gain control transistor Q4 on PCB 41-100 which controls the gain of the auto-ranging input amplifier IC9.

4.2.1.4 AUTO-RANGE AMPLIFIER

The auto-range amplifier accepts the noise, receive level or send level signal and adjusts its gain in 20 dB steps to keep the signal level within the detector operating range.

The auto-range amplifier consists of 4 cascaded 30 dB gain amplifier stages with individual FET gates to select the desired amplifier output. The first 20 dB gain amplifier IC9 also includes the 600/900 Ω gain adjustment circuit. The following 3 amplifiers IC10, IC11, and IC15 are identical and include a 20 dB gain amplifier stage with dc blocking, level detector diodes, a detector amplifier and a transistor logic gate which in conjunction with the other amplifiers opens the proper FET gate Q10, Q11, Q12, or Q13 to connect the output to the signal detector circuitry. Logic diodes D17, D18, D19, and D20 and driver transistors Q5, Q6 generate the range control signals for the digital display so that it matches the selected range of the auto-range amplifier.

4.2.1.5 DETECTORS

The auto-range amplifier output is buffered by unity gain amplifier IC14 which applies a signal to the quasi-rms detector used for noise detection and the average signal detector used for level detection. The detectors use a common full wave rectifier circuit

IC14A, IC12A which provide individual outputs for the average detector IC12B and the quasi-rms detector IC13B. Both detectors incorporate dc bias adjustments and the average detector has gain adjustment.

The detector outputs are routed to the 41-400 switchboard where the LEVEL switch S10B selects the proper detector for the selected measurement.

4.2.1.6 LOG CONVERTER

The log converter is located on the 41-200 board and takes the detected signal output and converts it to a gated clock signal whose duration is proportional to the logarithm of the input.

Capacitor C2 is charged to the detector output level through IC39. Every 320 ms the capacitor is disconnected from the detector and allowed to discharge to the reference voltage set by diode D1 and the voltage follower IC2B. The discharge period is converted to a sharp pulse by transistors Q4, Q5, and Q7. This pulse is synchronized with the 100 kHz clock by flip-flop IC6 to prevent partial clock pulses.

4.2.1.7 DIGITAL VOLTMETER

The gated clock output from the log converter, the range information from the auto-ranging amplifier, the update clock and unit (dBm, dBrn) control signals are processed by the digital voltmeter on the 41-100 board to provide a 3-digit plus sign level and noise readout directly in dBm/dBrn.

The number to be displayed is accumulated in the 4 pre-set decade counters IC25, IC26, IC27, and IC28. These counters take the gated clock pulse from the log converter and accumulate the hundredths, tenths, units and tens digits. The pre-set circuitry takes the range information from the auto-ranging amplifier and pre-sets the counters to the correct 20 dB range. Two sets of pre-set numbers are used: one for dB level measurements and the other for dBrn noise measurements.

The output of the pre-set counters are fed to the display latches IC29, IC30, and IC31 which drive the 7-segment displays located on the 41-300 board. Overrange blanking is controlled by the overrange detectors IC16A, IC16B which process the range and level information from the auto-ranging amplifier and the detector outputs to determine overrange/ underrange conditions. The remaining digital logic provides half digit and polarity displays, control of the decimal point, and blanking of the tenths dB digit during noise measurements.

4.2.1.8 MONITOR

The level or noise signal selected for display may also be monitored with the internal monitor amplifier and speaker.

The monitor signal is obtained from the output of the input amplifier of the auto-range amplifier. It is routed to the 41-400 board and the front panel monitor gain control R2. This control is connected to the monitor amplifier IC1 and the monitor driver transistors Q1, Q2. These transistors provide a low impedance drive directly to the monitor speaker.

4.2.2 FREQUENCY COUNTER

The frequency counter provides a 4-digit display with front-panel switch-selected 1 Hz or 10 Hz resolution. It makes use of a large scale integrated (LSI) counter IC with multiplexed display and the necessary external circuitry to provide analog signal processing, gating, reset/updating and leading zero suppression. It is located on the 41-200 board.

The counter analog signal input is derived from the third stage of the auto-ranging amplifier and is converted to logic levels in input amplifer IC16. This signal is run through differentiators C7, R31 and C8, R33 so that each zero crossing provides a pulse which effectively doubles the input frequency allowing display updates of 2/s rather than the 1/s which is commonly provided for 1 Hz resolution. The input to C8, R33 is disabled when 10 Hz resolution is used.

A 100 Hz clock signal is processed by counter IC19, the gate circuits IC18 and flip-flop IC20B to provide either the 1 Hz or 10 Hz resolution count gate selected by the front panel switch S11. Reset and update pulses are generated by the gates IC21, IC22, and IC23 with their corresponding RC time constants. Leading zero suppression is provided by flip-flop IC20 and the logic gates IC21, IC23.

The counter display may be turned off using the OFF front panel switch S13.

4.2.3 GENERATOR AND CLOCK

4.2.3.1 CLOCK

The clock circuitry located on the 41-200 board uses a 2 MHz crystal oscillator Y1, IC7 and a divider chain IC6, IC8, IC9, IC10 to provide the 500 kHz clock to the fixed frequency divider circuitry, the 100 kHz clock to the log converter, the 100 Hz clock to the frequency counter and generator lock circuitry and the 3.125 Hz update signal to the log converter and digital voltmeter.

The 2 MHz clock frequency may be adjusted using trimmer C6.

4.2.3.2 FIXED FREQUENCY GENERATOR

The fixed frequency generator provides the high accuracy, low distortion 1004 Hz holding tone available from the generator section. It is located on the 41-200 board.

A feedback counter arrangement using counter IC11 and digital gates IC12, IC13 divides the 500 kHz clock signal by 249. A final divide by 2-stage IC14 provides a symmetrical square wave to the 2-pole bandpass filter IC15. The filters provide better than 60 dB harmonic rejection providing a high purity sine wave at 1004.016 Hz. The filter output is fed to the 1004 HZ switch S16A of the 41-400 board which is used to select the desired generator output.

4.2.3.3 TUNEABLE GENERATOR

The tuneable generator uses a frequency locked oscillator, 100.4 Hz lock circuitry, a waveform generator and switchable filters to generate the variable frequency generator signal. It is located on the 41-200 board.

The frequency locked oscillator, IC26, operates at 20 times the generator output frequency and covers the range from 4 kHz to 400 kHz. An internal phase detector together with R58 and C19 doubles the oscillator output frequency by providing a pulse for each zero crossing. Its output is changed to a BCD number by the counter IC30 which drives the BCD to decade decoder IC32. The decoder outputs drive a precision resistor network which generates, as a result of the up/down counter operation, a 20 step replica of a positive half sine wave. This stairstep replica is buffered by amplifier IC33A and is inverted every other half cycle by the switched amplifier IC33B. This amplifier is switched from the inverting to the non-inverting configuration by 2 transmission gates under the control of divider flip-flop IC31.

The switchable filter IC25 filters the stairstep sine wave to provide a smooth low distortion sine wave. Four filter bandwidths are selected by the transmission gates controlled by the threshold detectors, IC28 and IC34. These threshold circuits monitor the frequency locked oscillator dc control voltage, which is proportional to frequency, to control the range over which each filter bandwidth is used.

The frequency locked oscillator may be tuned continuously using the front-panel frequency control R3 or locked in 100.4 Hz steps using the front-panel STEP switch S14. In the locked mode, the 100.4 Hz clock signal is buffered by amplifier IC25 and samples the sine wave generator output in transmission gate IC37. In the locked mode, this signal is summed through transistor Q16 with a voltage proportional to the frequency locked oscillator frequency derived by the charge pump discriminator IC27A, integrated by integrator IC27B, and applied to the oscillator frequency control input.

4.2.3.4 OUTPUT AMPLIFIER

The 1004 Hz fixed or tuneable generator output is selected by the 1004 Hz switch S16B on the 41-400 board. The signal is then applied to the front panel generator send level control R4 which is connected to the output amplifier IC38 on the 41-200 board to give a logarithmic control of output level over approximately a 25 dB range. This signal is coupled to the final output amplifier IC40 which provides the transformer coupled balanced output signal to the impedance determining networks and dc isolation capacitors on the 41-400 board.

The send level measurement signal and adjustment are provided after output amplifier IC38 and the SEND 600 Ω selector switch S18 provides the impedance level information to the auto-ranging circuitry for send level measurements.

4.2.4 POWER SUPPLY

The power supply is located on the 41-200 board and derives all the supply voltages from a -24 V dc source, the 115 V ac line or a -48 V dc source (optional).

The power supply is designed to operate from a positive ground -24 V dc source. This may be supplied externally from station battery or internally (ac operation) through transformer T1 located on the chassis and rectifier D19 and capacitor C38. To provide the positive and negative supply voltages required for the op/amps, a floating ground is derived from the 24 V supply. The IC regulator IC41 and pass transistor Q21 regulate the -24 V to -18 V dc. The splitting amplifier IC43 establishes a -9 V from the -18 V supply voltage which is used as the floating signal ground. Transistors Q22, Q23 provide additional current capacity for the floating ground.

The 5 V regulator IC42 and its pass transistor Q24 are referenced to the floating ground and provide the regulated +5 V used by the displays and digital logic.

The floating ground system does not affect measurements made by the test set because all input/output signals are transformer coupled.

When using conventional test equipment to calibrate or troubleshoot the Model 41, the test equipment connections described in Section 5.0 should be followed to prevent shorting of the chassis ground to the floating ground.

. When direct operation from a -48 V station battery is required, an optional pre-regulator is used. This pre-regulator consisting of a pass transistor and a Zener voltage reference diode regulates the 48 V supply to 24 V which is applied to the normal power supply input. Heat dissipation for the pre-regulator is provided by the optional heat sink bolted to the rear of the Model 41.

SECTION 5.0

MAINTENANCE AND CALIBRATION

5.1 MAINTENANCE PHILOSOPHY

Maintenance procedures for the Model 41 are divided into preventive and corrective classifications. Preventive maintenance consists of a routine performance check which may be made using the front panel controls of the instrument. Corrective maintenance covers the symptom analysis, troubleshooting, repair and recalibration of the instrument.

5.2 PREVENTIVE MAINTENANCE

5.2.1 GENERAL

The preventive maintenance procedures described in the following sections are used by the operator and the maintenance personnel to verify proper instrument operation using the front-panel controls. If proper operation is not achieved, see Section 5.3 for corrective maintenance procedures.

Periodic cleaning, lubrication or inspection of the Model 41 is not required.

The following checks are made by looping the Model 41 output to the Model 41 input. Connections between the output and input terminals may be made using an appropriate test cord.

5.2.2 GENERATOR

This section contains the self-checks that may be used for the generator section of the Model 41. If proper operation of the Model 41 receiver section is in doubt, an external frequency counter and voltmeter may be used to check the generator.

5.2.2.1 1004 GENERATOR

Starting from left to right, depress the following Model 41 pushbuttons: 600 Ω, TERM, REC, C-MSG, 1HZ, 1004 HZ, and 600 Ω. Connect the input and output terminals together with an appropriate test cord. Using the send level control, adjust the output for a reading of +90 dBrn on the Model 41. The counter should indicate a frequency of 1.004 kHz ±1 Hz. Depress the NOTCH pushbutton and verify that the Model 41 reads less than +40 dBrn.

5.2.2.2 FREQUENCY RANGE

Depress the dBm pushbutton marked LEVEL and the generator pushbutton marked CONT. Using the front-panel frequency control knob, vary the frequency over its entire range and verify that the frequency range covers at least 200 Hz to 20 kHz.

5.2.2.3 100.4 HZ STEP

Depress the generator pushbutton marked STEP. Using the front panel frequency control, vary the frequency from the range 200 Hz to 20 kHz and verify that the frequency changes in 100.4 Hz steps.

5.2.2.4 GENERATOR LEVEL RANGE

Depress the generator pushbutton marked 1004 HZ. Using the front-panel level control knob, vary the level over its range and verify that the send level includes the range +10.0 dBm to -40.0 dBm.

5.2.3 FREQUENCY COUNTER

Depress the 1 HZ pushbutton. Using the Model 41 generator, vary the frequency from 200 Hz to 10 kHz and verify that the frequency counter follows the generator output.

Depress the 10 HZ pushbutton. Using the Model 41 generator, vary the frequency from 10 kHz to 20 kHz and verify that the frequency counter follows the generator output.

Depress the frequency counter OFF pushbutton and verify that the display blanks.

5.2.4 AUDIO MONITOR

Depress the display pushbutton marked SEND and the generator pushbutton marked 1004 HZ. Using the front-panel level control knob, adjust the send level for a reading of 0.0 dBm on the Model 41. Adjust the monitor level control and verify the presence of a 1004 Hz tone from the speaker. The speaker output should increase in level as the monitor control is turned clockwise.

5.2.5 RECEIVER

This section contains the various checks for the receive section of the Model 41. Once proper operation of the generator section has been verified, the Model 41 generator may be used as the input signal to the Model 41 receiver.

5.2.5.1 FREQUENCY RANGE

Depress the receive pushbuttons marked 600 Ω and TERM, the display pushbutton marked REC, DBM pushbutton marked LEVEL, the KHZ pushbutton marked 1 HZ, the GENERATOR pushbutton marked CONT, and the SEND pushbutton marked 600 Ω. Using the front-panel frequency control knob, adjust the generator frequency for a frequency of 1000 Hz ±10 Hz. Using the front-panel level control, adjust the generator output level to 0.0 dBm. Using the frequency control knob, adjust the frequency for 200 Hz to 4 kHz and verify that the Model 41 display indicates 0.0 ±0.3 dB. Vary the frequency from 4 kHz to 20 kHz and verify that the Model 41 indicates 0.0 dB ±0.5 dB.

5.2.5.2 LEVEL RANGE

Place an external attenuator with an overall accuracy of 0.1 dB or better between the send output and the receive input. Set the input to 0.0 dBm at a frequency of 1000 Hz ±10 Hz. Vary the input level over the range of +10.0 to -40.0 dBm and verify that the Model 41 indicates a correct level ±0.2 dB. Vary the input level over the range of -40.0 to -70.0 dBm and verify that the Model 41 indicates the correct level ±1.0 dB.

5.2.5.3 3 KHZ FILTER

With the notch pushbutton out and the 3 kHz pushbutton in, adjust the Model 41 receiver input to a frequency of 1000 Hz ±10 Hz. Adjust the level so that the Model 41 display flashes between +89 and +90 dBrn. Without changing the input level, change the input frequency to 3000 Hz ±10 Hz and verify that the Model 41 display indicates +87 dBrn.

5.2.5.4 C-MESSAGE FILTER

With the notch pushbutton out and the C-Message pushbutton in, adjust the frequency to 1000 Hz ±10 Hz. Adjust the level so that the Model 41 display flashes between +89 and +90 dBrn. Without changing the input level, change the input frequency to 3700 Hz ±20 Hz and verify that the Model 41 display indicates a level of +80 dBrn ±2 dBrn.

5.2.5.5 NOTCH FILTER

Depress both the notch pushbutton and the C-Message pushbutton. Set the receive input to a frequency of 2000 Hz ±10 Hz at a level of +90 dBrn. Without changing the level, change the input frequency to 1000 Hz ±10 Hz. Verify that the Model 41 indicates a level of +40 dBrn or less.

5.3 CORRECTIVE MAINTENANCE

5.3.1 TROUBLESHOOTING

This section covers symptom analysis, circuit level troubleshooting and calibration procedures for the Model 41.

No specialized mechanical assembly or disassembly procedures are required. Accepted practices should be followed when repair is undertaken on mainframe components or the printed circuit boards. Recommended troubleshooting techniques are based on signal tracing methods where a known input signal is used and the level and waveforms are verified as the signal progresses through the circuitry.

5.3.2 SYMPTOM ANALYSIS

The preventive maintenance checks of Section 5.2 are used to isolate the area in which malfunction occurs. Table 5-1 summarizes possible fault location for each of the preventive maintenance tests.

TABLE 5-1

SYMPTOM ANALYSIS

PREVENTIVE MAINTENANCE TEST	PROBABLE TROUBLE LOCATION
1. No response from any test	a. AC power cord b. Fuse c. Internal ac wiring or power switch d. Power supply
2. 1004 Hz generator check (5.2.2.1)	a. Output amplifier IC38 or IC40 b. 1004 Hz filter IC15 c. 1004 Hz divider IC12, IC13, or IC11 d. Crystal oscillator or divider IC6, IC7, IC8, or IC9 e. 1004 Hz switch S16
3. Generator frequency check (5.2.2.1)	a. VCO IC26 b. Divider IC29, IC30, IC31 c. Sine wave converter IC32, IC33 d. Output filters IC25, IC35, IC36, IC37 e. Discriminator IC27 f. VCO control IC28, IC34
4. 100.4 Hz step test (5.2.2.3)	a. 100.4 Hz input IC25, IC37 b. 100.4 Hz lock IC27, Q6
5. Level range check (5.2.2.4)	a. Output amplifier IC38, IC40 b. Output transformer T1
6. Frequency counter check (5.2.3)	a. Input or auto-range amplifiers IC1, IC9, IC10, IC11, IC15 b. Input IC9 or Q4 on 41-100 board c. 10 Hz resolution D9, D10, IC17 d. Counter control IC17 through IC24 e. Digit drivers Q11 through Q14, IC24 f. Segment drivers Q15 through Q20, Q8
7. Audio monitor check (5.2.4)	a. Input amplifier IC1 b. Summing amplifier IC9 c. Monitor amplifier IC1, Q1, Q2 on 41-400 board
8. Receive frequency range check (5.2.5.1)	a. Input amplifier IC1 b. Auto-range amplifier IC9, IC10, IC11, IC15 c. Detectors IC12, IC13, IC14

TABLE 5-1 continued

PREVENTIVE MAINTENANCE TEST	PROBABLE TROUBLE LOCATION
9. Receiver level check (5.2.5.2)	a. Auto-range amplifier IC9, IC10, IC11, IC15 b. DVM control IC18, IC19, IC21, IC33, IC35, IC22 c. DVM counters IC24 through IC34
10. 3 kHz filter check (5.2.5.3)	a. 3 kHz filter IC2 b. Noise amplifier IC1 on 41-400 board
11. C-Message filter check (5.2.5.4)	a. 3 kHz filter IC2 b. Noise amplifier IC1 on the 41-400 board
12. Notch filter check (5.2.5.5)	a. Notch filter IC5, IC6, IC7, IC8 b. Filter switches S7, S8, S9

5.3.3 CIRCUIT LEVEL TROUBLESHOOTING

The following sections describe the general procedures to be used in locating malfunctions. Where appropriate, performance standards, voltage levels, or waveform descriptions are provided to assist in the troubleshooting procedure. Unless otherwise stated, all voltage and frequency tolerances are ±10% and all dB tolerances are ±0.1 dB. When a circuit has the proper input signal, but the correct output cannot be measured, the components associated with that circuit should be checked and replaced if defective. Before detailed troubleshooting is undertaken, the ±9 V power supply voltages should be checked. Low supply voltages may result from a malfunctioning power supply or excessive current being drawn by a defective circuit. A defective integrated circuit may often be located by feeling the case temperature. Normally, the integrated circuits are moderately warm to the touch. However, when defective, they can become extremely warm, causing a painful sensation when touched.

The local system ground used in the Model 41 is not at the same potential as chassis or earth ground. For this reason floating test equipment should be used. When floating test equipment is not available, the unit must be operated on the ac line supply, and the black wire connected to the + terminal on the 41-200 board must be

disconnected. Connection to the local ground can be made at the junction of the negative terminals of C42 and C44 toward the rear of the 41-200 board.

5.3.3.1 POWER SUPPLY (41-200 BOARD)

Using a dc voltmeter, measure the voltage from the negative end of C46 to the positive end of C44. This voltage should be 18.0 V dc ±0.5 V. If the correct voltage is not present, then IC41 or Q21 is most likely defective.

If the correct voltage is present, monitor the voltage across C44 and C46. This voltage should be 9.0 V dc ±0.3 V. If the correct voltage is not present, then IC43, Q22, or Q23 is defective.

Monitor the voltage across capacitor C 42. This voltage should be 5.0 V dc ±0.1 V. If this voltage is not present, disconnect the jumper wire connecting the 5 V supply to the PC board. If the correct voltage is not present, then IC42 or Q24 is most likely defective. If the correct voltage is present, then there is most likely a malfunction on the PC board that is loading down the power supply.

5.3.3.2 CRYSTAL OSCILLATOR AND DIVIDERS (41-200 BOARD)

Using an oscilloscope with a calibrated time base, monitor the signal at Pin 12 of IC6 on the 41-200 board. This signal should be a 1 MHz, 5 V square wave. If this signal is not correct, check the 2 MHz oscillator IC7 or the divide by two IC6.

Monitor the signal at Pin 5 of IC8. This signal should be a 5 V square wave with a duty cycle ratio of 40/60 and a frequency of 100 Hz.

Monitor the signal at Pin 13 of IC8. This signal should be a 5 V square wave at a frequency of 10 kHz and a duty cycle ratio of 40/60.

Monitor the signal at Pin 13 of IC9. This signal should be a 5 V square wave at a frequency of 100 Hz and a duty cycle ratio of 40/60.

Monitor the signal at Pin 14 of IC9. This signal should be a 5 V square wave at a frequency of 100 Hz and a duty cycle ratio of 20/80.

Monitor the signal at Pin 12 of IC10. This signal should be a 5 V square wave with a period of 320 ms and a duty cycle ratio of 50/50.

Monitor the signal at Pin 13 of IC3. This signal is a 5 V level which drops to 0 V for 80 ms every 320 ms.

Monitor the signal at Pin 5 of IC19. This signal should be a 5 V square wave at a frequency of 10 Hz and a duty cycle ratio of 40/60.

Monitor the signal at Pin 13 of IC19. This signal should be a 5 V square wave at a frequency of 2 Hz and a duty cycle ratio of 40/60.

5.3.3.3 1004 HZ FREQUENCY GENERATOR (41-200 BOARD)

Monitor the signal at Pin 4 of IC13. This signal should be a 5 V pulse whose duration is approximately 1.5 µs and occurs every 498 µs.

Monitor the signal at Pin 1 of IC14. This signal should be a 5 V square wave at a frequency of 1004 Hz with a duty cycle ratio of 50/50.

Monitor the signal at Pin 1 of IC15. This signal should be a 1004 Hz sine wave at a level of 0.0 dBm ±1.5 dB.

5.3.3.4 FREQUENCY GENERATOR (41-200 BOARD)

Any malfunction in the frequency generator can best be isolated by waveform tracing using the timing diagram in Figure 5-1. Set the controls for a generator output of 1000 Hz ±5 Hz at a level of 0.0 dBm ±0.5 dB.

Using the negative going edge of waveform C as a trigger, verify the correct operation of the generator by observing the correct waveforms at the test points listed. If the correct waveform is not observed, the gate or counter associated with that waveform is most likely defective.

At frequencies other than 1000 Hz, the waveform shapes will be the same but the time base will be different.

5.3.3.5 100.4 HZ STEP (41-200 BOARD)

Using an oscilloscope, observe the waveform at Pin 7 of IC25. This waveform should be a short pulse varying from approximately -8 V to +8 V at a 100.4 Hz rate. The duration of the pulse at the bottom of the waveform should be approximately 30 µs.

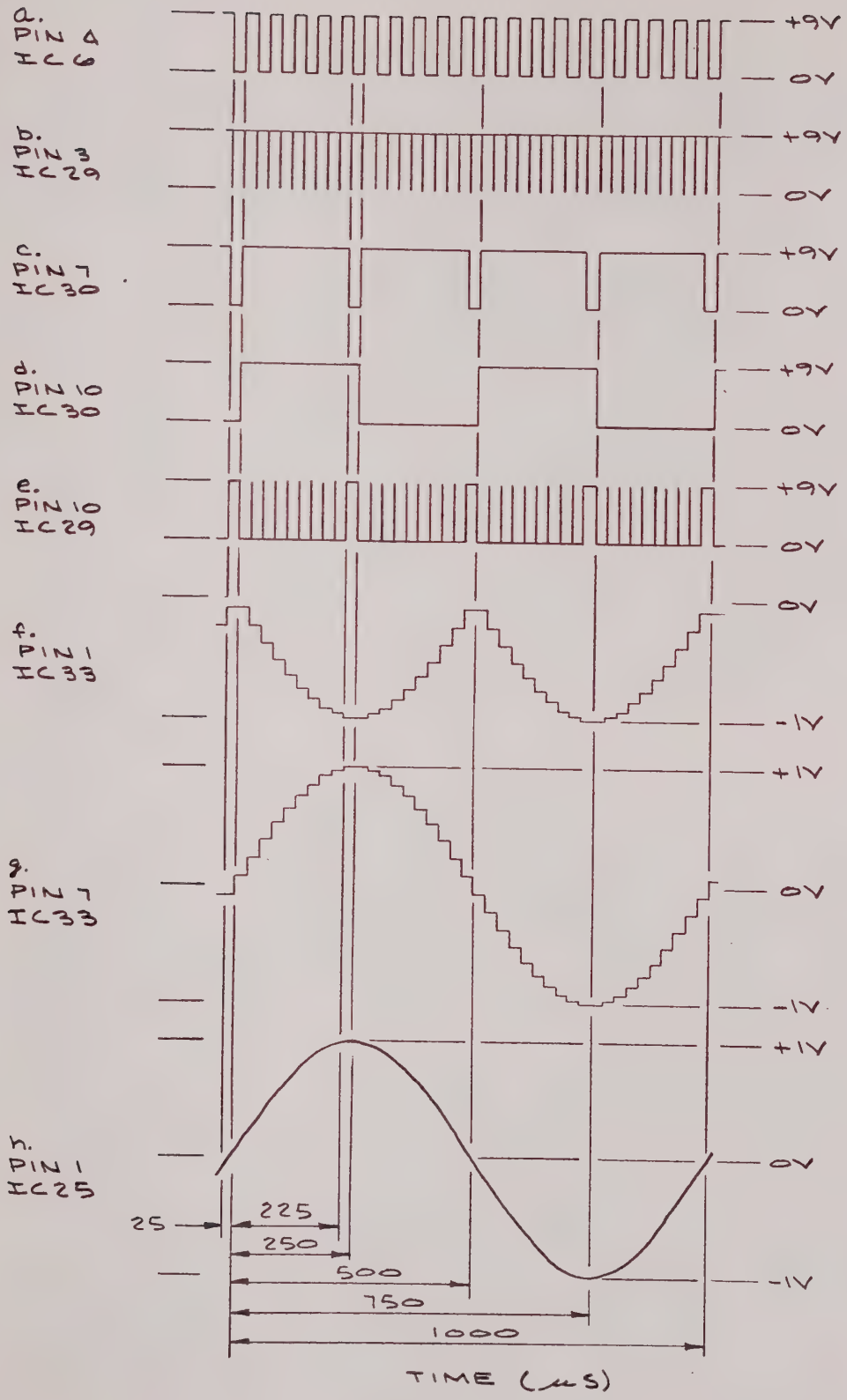


FIGURE 5-1 GENERATOR TIMING DIAGRAM

If this waveform is not present, then IC25 is most likely defective. If this waveform is present, then IC37 or Q6 is most likely defective.

5.3.3.6 SEND OUTPUT FILTERS (41-200 BOARD)

Using an oscilloscope, observe the signal at Pin 1 of IC25. As the generator frequency is varied from 200 Hz to 20 kHz, this output should be a clean sine wave with a peak value of 1.1 V ±0.2 V. If this signal is not present or has wide variations in signal level as the frequency is varied, then IC25 is most likely defective. If this signal is present over a portion of the frequency range, then comparitors IC28 and IC34 or switches IC35, IC36, and IC37 may be defective.

At a frequency of 300 Hz, Pin 1 of IC28 should be approximately +7.5 V and IC35 should be on. At a frequency of 1000 Hz, the voltage at Pin 1 of IC34 should be +7.5 V and IC36 should be switched on. At a frequency of 5000 Hz, Pin 7 of IC34 should be approximately +7.5 V and switch IC37 should be switched on.

5.3.3.7 OUTPUT AMPLIFIER (41-200 BOARD)

Adjust the operating controls for an output of 1000 Hz with a 600 Ω impedance. Using an ac voltmeter, monitor the signal at Pin 6 of IC38. As the level control is varied over its full range, this signal should vary over the range of at least -43.5 dB to +6.5 dB. If the signal does not vary at least over this range, then IC38 is most likely defective.

Monitor the signal at Pin 6 of IC40. This signal should vary over the range of at least -37.5 dB to +12.5 dB. If the signal does not vary over at least this range, then IC40 is most likely defective.

5.3.3.8 FREQUENCY COUNTER (41-200 BOARD)

Set the controls to monitor the send frequency and adjust the send frequency to 1000 Hz. Monitor the signal at Pin 6 of IC16. This signal should be a square wave at the send frequency.

Monitor the signal at Pin 10 of IC17. With the 1 Hz resolution button pushed in, it should be a pulse at twice the input frequency rate. With the 10 Hz resolution button pushed in, it should be a pulse at the input frequency rate.

Monitor the signal at Pin 4 of IC18. With the 1 Hz resolution button pushed in, it should be a 2 Hz square wave. With the 10 Hz resolution button pushed in, it should be a 10 Hz square wave.

Monitor the signal at Pin 4 of IC24. This signal should be the same as the frequency at Pin 10 of IC17 which is gated on and off by the signal at Pin 13 of IC20. The signal at Pin 2 and Pin 3 should be short negative pulses with a pulse duration of approximately 2 μs.

With the 1 Hz resolution button pushed in, apply an input signal greater than 10 kHz. Pin 6 of IC24 should then go negative and Pin 12 of IC21 should go positive enabling the blinking signal on Pin 12 of IC19. Under these conditions, the display should blink on and off. This blinking signal is coupled from Pin 11 of IC21 through D6 to the 41-400 board and then back to Pin 6 of IC23 of the 41-200 board.

If any one digit is not illuminated, then either the LED display or its digit driver is defective. The digit drivers are controlled by IC24 Pins 20 through 23. Under normal operation, each one of these pins is high for 25% of the time. If any segment on any one display is defective, then that display is most likely defective. If a segment is defective on all of the displays, then the segment driver is most likely defective. The segment drivers are controlled by IC24 Pins 13 through 19.

5.3.3.9 AUDIO MONITOR (41-400 BOARD)

The audio monitor amplifier consists of IC1, Q1, and Q2 on the 41-400 board. Monitor the signal at Pin 3 of IC1. If no signal is present, then IC9 or IC1 on the 41-100 board is most likely defective. If the signal is present, monitor the signal at the emitter of either Q1 and Q2. This signal should be an amplifier version of the signal at Pin 3 of IC1. Some crossover distortion at this point is normal. If the signal is not present, then either IC1, Q1, or Q2 is defective. If the signal is present but no sound is heard, then the speaker is most likely defective.

5.3.3.10 RECEIVE INPUT AMPLIFIER (41-400 BOARD)

Apply an input signal of 0.0 dBm at a frequency of 1 kHz. Monitor the signal at Pin 6 of IC1. This signal should be a 1 kHz sine wave at a level of approximately 0.0 dBm. If this signal is not present, then the input termination or blocking capacitors are most likely defective.

Monitor the signal at Pin 7 of IC9. This signal should be a 1 kHz sine wave at a level of 0.0 dBm ±0.5 dB. If this signal is not present, verify that the signal is present at the input at Pin 12 of FC1. If the signal is present at the input, but not at Pin 7 of IC9, then either IC9 is defective or the send/receive switches Q1 through Q3 are defective.

Switching the 600 and 900 Ω terminations should cause a gain change of 1.5 dB ±0.2 dB at Pin 7 of IC9. If this gain change does not occur properly, then Q4 is most likely defective.

5.3.3.11 3 KHZ FILTER (41-100 BOARD)

With the notch pushbutton out and the 3 kHz button in, monitor the signal at FC1 Pin 6. Apply an input signal of 1000 Hz at a level of 0.0 dBm. This signal should be present at Pin 6 of FC1. If the signal is not present, then IC1 on the 41-100 board is most likely defective. If the signal is present, monitor the signal at Pin 7 of IC1 on the 41-400 board. If the signal is not present, then either IC1 or switch S7 is defective.

5.3.3.12 C-MESSAGE FILTER (41-100 BOARD)

With an input frequency of 1000 Hz at a level of 0.0 dBm, verify the presence of a signal at Pin 7 of IC1 on the 41-400 board as described in Section 5.3.3.10. If this signal is present, observe the signal at Pin 7 of IC2, Pin 1 of IC3, Pin 7 of IC3, Pin 7 of IC4 and Pin 1 of IC4. The 1 kHz signal should be present at each one of these points with a slight variation in level. If the signal is present at one point but not at the next point, then that IC is most likely defective.

5.3.3.13 NOTCH FILTER (41-100 BOARD)

Depress both the notch filter and the 3 kHz filter button. Apply an input signal of 1000 Hz at a level of 0.0 dBm. Monitor the signal at Pin 7 of IC1 on the 41-400 board. Verify that the signal is present when the notch button is out but is not present when the notch button is pushed in. With the notch button in,the level at Pin 7 of IC1 should drop at least 50 dB provided the total harmonic distortion of the input signal is less than 56 dBm.

If the correct signals are not present at Pin 7 of IC1, perform the notch filter calibration alignment as described in Section 5.3.4.5 of this manual. If any one section of the notch filter is not aligned properly, then that section of the filter is most likely defective.

5.3.3.14 AUTO-RANGE AMPLIFIER (41-100 BOARD)

Set the controls to monitor receive level and apply an input signal at a frequency of 1000 Hz at a level of 0.0 dBm. Monitor this signal at Pin 7 of IC14. This signal should be the 1000 Hz sine wave at a level of 0.0 dBm ±0.5 dB. If this signal is not present, then IC14 or Q13 may be defective.

Decrease the input level to -20.0 dBm. The level at Pin 7 of IC14 and Pin 7 of IC10 should be 0.0 dBm ±0.5 dB. If this signal is not present, then IC14 or Q13 may be defective.

Decrease the input level to -40.0 dBm. Monitor the signal at Pin 7 of IC14 and Pin 7 of IC11. This signal should be at a level of 0.0 dBm ±0.5 dB. If the signal is present at IC14 but not IC11, then Q11 is most likely defective. If the signal is not present at IC11, then IC11 is most likely defective.

Decrease the input level to -60.0 dBm. Monitor the signal at Pin 7 of IC14 and Pin 7 of IC15. This signal should be at a level of 0.0 dBm ±0.5 dB. If the signal is not present at IC14 but is present at IC15, then IC15 is most likely defective.

5.3.3.15 DETECTORS (41-100 BOARD)

Apply an input signal of 1000 Hz at a level of 0.0 dBm. Monitor the signal at the emitter Q15 of Q17. In each case the signal should be a 1000 Hz sine wave at a level of 0.0 dBm ±0.5 dB. The level at both points should be the same but with opposite phase. If the signal is not present at the emitter of Q15, then either Q14, Q15, or IC14 is defective. If the correct signal is not present at the emitter of Q17, then Q16, Q17, or IC12 is defective.

Monitor the signal at Pin 7 of IC12. This should be a dc voltage of approximately +2 V. If the signal is not present, then IC12 is most likely defective.

5.3.3.16 LOG CONVERTER (41-200 BOARD)

Apply an input signal of 1000 Hz at a level of 0.0 dBm. Using Figure 5-2, monitor the waveform at the test point indicated. If the correct waveform is not present at a particular test point, then the IC pertaining to that test point is most likely defective.

5.3.3.17 DIGITAL VOLTMETER CONTROLS (41-100 BOARD)

Set the controls to monitor receive level. Apply an input signal of 1000 Hz at a level of 0.0 dBm. Monitor the signal at the collectors of Q5 and Q6. A high signal corresponds to a voltage of +5 V. A low signal corresponds to a level of 0 V.

With an input of 0.0 dBm, both Q5 and Q6 should be low.

With a level of -20.0 dBm, Q5 should be high and Q6 should be low.

With an input level of -40.0 dBm, Q5 should be low and Q6 should be high.

With an input level of -60.0 dBm, both Q5 and Q6 should be high.

With an input signal of 0.0 dBm, Pin 12 of IC25 should be high and Pins 3, 4 and 13 should be low.

With an input level of -20.0 dBm, Pin 13 of IC25 should be high and Pins 3, 4 and 12 should be low.

With an input level of -40.0 dBm, Pins 12 and 13 of IC25 should be high and Pins 3 and 4 should be low.

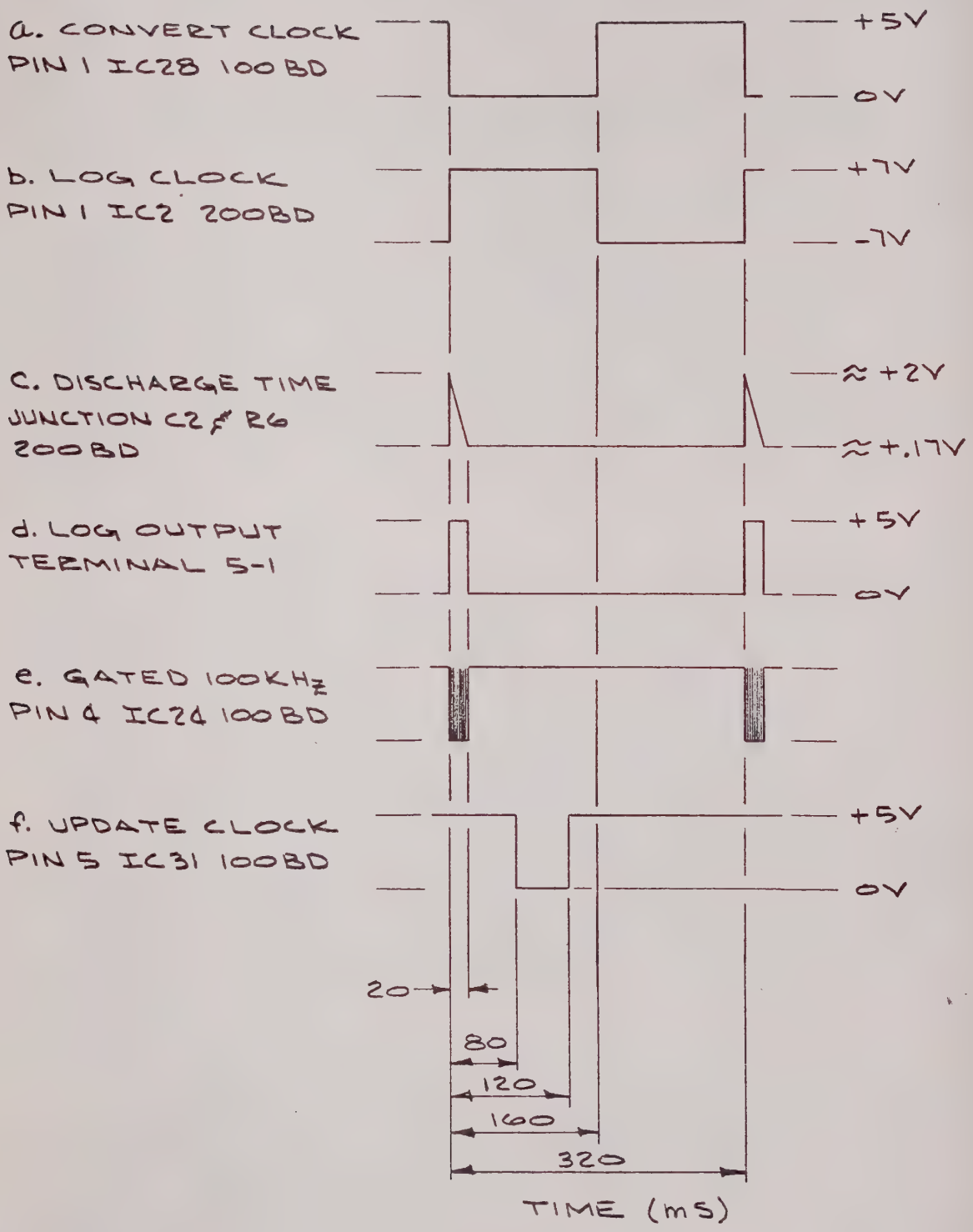


FIGURE 5-2 VOLTMETER TIMING DIAGRAM

With an input level of -60.0 dBm, Pin 3 of IC25 should be high and Pins 4, 12, and 13 should be low.

5.3.3.18 DIGITAL VOLTMETER SEGMENT DRIVERS (41-100 BOARD)

Set the controls to monitor receive level. Apply an input signal of 1000 Hz at a level of 0.0 dBm.

The information from the counters IC25 through IC28 is coupled to the segment drivers IC29 through IC31 in a BCD code format. If the correct segments are not illuminated, verify that the correct BCD code is present at the input to the segment driver. If the correct code is present but the correct segment is not illuminated, then the segment is most likely defective. If the correct code is not present, then the counter corresponding to that segment driver is most likely defective.

5.3.4 CALIBRATION

The following procedures are used to recalibrate the generator and receiver circuitry. Recalibration is normally required when maintenance has been performed on associated circuitry or when there is a reason to suspect that calibration is no longer accurate.

The local system ground used in the Model 41 is not at the same potential as chassis or earth ground. For this reason, floating test equipment should be used when making the following adjustments. When floating test equipment is not available, the unit must be operated on the ac line supply, and the black wire connected to the + terminal on the 41-200 board must be disconnected. Connection to the local ground can be made at the junction of the negative terminals of C42 and C44 toward the rear of the 41-200 board.

5.3.4.1 POWER SUPPLY (41-200 BOARD)

Step A. Connect a digital dc voltmeter from the positive end of capacitor C44 and the negative end of capacitor C46.

Step B. Adjust resistor R152 for a reading of 18.0 V dc ±0.5 V dc on the voltmeter.

Step C. Connect the digital dc voltmeter across capacitor C42.

Step D. Adjust resistor R160 for a reading of 5.00 V dc ±0.02 V.

5.3.4.2 LOW FREQUENCY SET (41-200 BOARD)

Step A. Set the generator to the continuous mode.

Step B. Monitor the output signal at the output terminal using an ac voltmeter and frequency counter.

Step C. Set the level control for an output of -10.0 dBm ±0.2 dBm.

Step D. Set the frequency control on the Model 41 to the fully counterclockwise position.

Step E. Adjust resistor R69 for an output frequency of 175 Hz ±2 Hz. R69 may be adjusted through the access hole in the 41-400 board.

5.3.4.3 SIGNAL PURITY ADJUSTMENT (41-200 BOARD)

Step A. Set the frequency control on the Model 41 for an output of 1010 Hz ±10 Hz.

Step B. Set the send level to 0.0 dBm ±0.2 dBm.

Step C. Connect the Model 41 send output to a 1010 Hz Notch Filter. Monitor the notch filter output on an ac voltmeter.

Step D. Adjust R85 and R92, in turn, for a minimum reading on the ac voltmeter. R85 and R92 may be adjusted through the access hole in the 41-400 board.

5.3.4.4 1004 HZ BANDPASS FILTERS (41-200 BOARD)

Step A. Using an ac voltmeter, monitor the signal at Pin 7 of IC15.

Step B. Using a short clip lead, ground the junction of capacitors C16 and C17 near FC4.

Step C. Adjust R48 for a maximum signal reading on the voltmeter (≃ +6 dB).

Step D. Remove the clip lead from the junction of C16 and C17.

Step E. Adjust R52 for a minimum signal reading on the voltmeter (≃ -2 dB).

5.3.4.5 NOTCH FILTER ALIGNMENT (41-100 BOARD

Step A. Set the Model 41 to the 3 kHz plus notch measurement mode.

Step B. Set the receiver input to 600 Ω terminated.

Step C. Apply an input frequency of 1010 Hz ±1 Hz at a level of 0.0 dBm ±0.2 dBm to the Model 41 input.

Step D. Monitor the notch filter output at Pin 7 of IC8 using an ac voltmeter.

Step E. Using short clip leads, place jumper wires across capacitors C17, C20 and C23.

Step F. Adjust R55 and R59, in turn, for a null on the ac voltmeter.

Step G. Remove the jumper wire from C23 and connect it across C26.

Step H. Adjust R44 and R49 for a null on the ac voltmeter.

Step I. Remove the jumper wire from C20 and connect it across C23.

Step J. Adjust R35 and R40 for a null on the ac voltmeter.

Step K. Remove the jumper wire from C17 and connect it across C20.

Step L. Adjust R23 and R28 for a null on the ac voltmeter.

Step M. Remove the jumper wires across C20, C23, and C26.

5.3.4.6 C-MESSAGE FILTER ALIGNMENT (41-400 BOARD)

Step A. Set the Model 41 to the C-MSG without notch measurement mode.

Step B. Apply an input signal of 2 kHz ±5 Hz at a level of -10.0 dBm ±0.1 dBm to the input terminals.

Step C. Monitor the signal at Pin 1 of IC4 using an ac voltmeter.

Step D. Change the input frequency to 1 kHz ±5 Hz and adjust R4 for a reading 1.3 dBm ±0.2 dBm above the value in Step C.

Step E. Repeat Steps C and D until no further adjustment is required.

5.3.4.7 600 Ω CALIBRATION (41-100 BOARD)

Step A. Set the Model 41 to the receiver level measurement mode.

Step B. Set the receiver input to 600 Ω terminated.

Step C. Apply an input frequency of 1004 Hz ±5 Hz at a level of 0.00 dBm ±0.05 dBm referenced to 600 Ω.

Step D. Monitor the signal at Pin 7 of IC14 using the ac voltmeter.

Step E. Adjust R71 for a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter.

5.3.4.8 900 Ω CALIBRATION (41-100 BOARD)

Step A. Set the Model 41 to the receiver level measurement mode.

Step B. Set the receiver input to 900 Ω terminated.

Step C. Apply an input signal of 1004 Hz ±5 Hz at a level of 0.00 dBm ±0.05 dBm referenced to 900 Ω.

Step D. Monitor the signal at Pin 7 of IC14 using the ac voltmeter.

Step E. Adjust R69 for a reading of 0.00 dBm ±0.05 on the ac voltmeter.

5.3.4.9 SEND LEVEL CALIBRATION (41-200 BOARD)

Step A. Set the Model 41 to the send level measurement mode with 600 Ω output impedance.

Step B. Connect a 600.0 Ω ±0.6 Ω terminating resistor to the Model 41 output terminals.

Step C. Monitor the output across the 600 Ω terminating resistor using a digital ac voltmeter.

Step D. Using the 100.4 Hz step mode, adjust the send signal for a frequency of 1004 Hz at a level of 0.7746 V ac ±0.002 V ac as measured with the digital ac voltmeter across the 600 Ω terminating resistor.

Step E. Monitor the signal at Pin 7 of IC14 on the 41-100 board using an ac voltmeter.

Step F. Adjust R81 to give a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter at Pin 7 of IC14.

Step G. Set the Model 41 output to the fixed 1004 Hz mode.

Step H. Adjust R53 for an output of 0.7746 V ac ±0.002 V ac as measured on the digital ac voltmeter.

5.3.4.10 NOISE CALIBRATION (41-100 BOARD)

Step A. Set the Model 41 to the 3 kHz without notch measurement mode.

Step B. Set the receiver input to 600 Ω terminated.

Step C. Apply an input signal of 1000 Hz ±5 Hz at a level of 0.00 dBm ±0.05 dBm.

Step D. Monitor the signal at Pin 7 of IC14 using an ac voltmeter.

Step E. Adjust R4 on the 41-400 board for a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter.

Step F. Set the Model 41 to the C-MSG without notch measurement mode.

Step G. Adjust R60 on the 41-100 board for a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter.

Step H. Change the input frequency to 300 Hz ±5 Hz at a level of 0.00 dBm ±0.05 dBm.

Step I. Set the Model 41 to the 3 kHz plus notch measurement mode.

Step J. Adjust R19 on the 41-100 board for a reading of 0.00 dBm ±0.05 dBm.

5.3.4.11 AUTO-RANGING GAIN CALIBRATION (41-100 BOARD)

Step A. Set the Model 41 to the receive level measurement mode.

Step B. Apply an input signal of 1000 Hz ±5 Hz at a level of -20.00 dBm ±0.05 dBm.

Step C. Monitor the signal at Pin 7 of IC14 using an ac voltmeter.

Step D. Adjust R74 for a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter.

Step E. Set the input level to -40.00 dBm ±0.05 dBm.

Step F. Adjust R79 for a reading of 0.00 dBm ±0.05 dBm on the ac voltmeter.

Step G. Set the input level to -60.00 dBm ±0.05 dBm.

Step H. Adjust R84 for a reading of 0.00 dBm ±0.05 on the ac voltmeter.

5.3.4.12 LEVEL DETECTING CALIBRATION (41-100 BOARD)

Step A. Set the Model 41 to the receive level measurement mode.

Step B. Set the receive input to 600 Ω terminated.

Step C. Monitor the dc voltage of Pin 7 of IC12 using a digital dc voltmeter.

Step D. Set the input signal to a frequency of 1000 Hz at a level below -12.0 dBm and then increase to -10.0 dBm ±0.05 dBm.

Step E. Adjust R126 for a reading of 6.000 V dc ±0.006 V dc on the dc voltmeter.

Step F. Set the input level above -8.0 dBm and then decrease to -10.00 dBm ±0.05 dBm.

Step G. Adjust R129 for a reading of 0.600 V dc ±0.002 V dc on the dc voltmeter.

Step H. Repeat Steps D through G until no further adjustment is required.

5.3.4.13 LOG CONVERTER CALIBRATION (41-200 BOARD)

Step A. Set the Model 41 to the receive level measurement mode.

Step B. Set the receiver input to 600 Ω terminated.

Step C. Set the input signal to 1000 Hz ±5 Hz to a level of less then -12.0 dBm and then increase to -10.00 dBm ±0.05 dBm.

Step D. Adjust R10 for a reading of -10.0 dBm on the Model 41.

Step E. Set the input signal level to greater than -8.0 dBm and then decrease to -10.00 dBm ±0.05 dBm.

Step F. Adjust R15 for a reading of -10.0 dBm on the Model 41.

Step G. Repeat Steps C through F until no further adjustment is required.

5.3.4.14 NOISE DETECTOR CALIBRATION (41-100 BOARD)

Step A. Monitor the dc voltage at Pin 7 of IC13.

Step B. Using a short clip lead, ground the positive end of capacitor C38.

Step C. Adjust R135 for a reading of 0.000 V dc ±0.005 V dc on the dc voltmeter.

Step D. Remove the clip lead from the positive ends of C38.

Step E. Set the Model 41 to the receive level measurement mode.

Step F. Set the input signal to 1000 Hz ±5 Hz at a level of -10.5 dBm as read on the Model 41.

Step G. Set the Model 41 to 3.0 kHz without notch measurement mode.

Step H. Adjust R4 on the 41-400 board so that the Model 41 meter reading just switches between +79 and +80 dBrn.

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C1, C2	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C3, C4	Capacitor, Polystyrene .1 mfd, 63 V, 1%	611	M.I.A.L.
	C5	Capacitor, Polystyrene .013 mfd, 63 V, 1%	611	M.I.A.L.
	C6	Capacitor, Polystyrene 4700 pf, 63 V, 1%	611	M.I.A.L.
	C7	Capacitor, Polystyrene .015 mfd, 63 V, 1%	611	M.I.A.L.
	C8	Capacitor, Polycarbonate, .47 mfd, 100 V, 5%	B32541	Siemens
	C9	Capacitor, Polystyrene 3900 pf, 63 V, 1%	611	M.I.A.L.
	C10	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C11	Capacitor, Polystyrene .027 mfd, 63 V, 1%	611	M.I.A.L.
	C12	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C13	Capacitor, Polystyrene 220 pf, 63 V, 1%	611	M.I.A.L.
	C14	Capacitor, Polystyrene 5000 pf, 63 V, 1%	611	M.I.A.L.
	C15	FACTORY SELECT		
	C16, C17	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C18	Capacitor, Dipped Mica 470 pf, 500 V, 5%	DM15	
	C19, C20	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C21	Capacitor, Dipped Mica 820 pf, 5000 V, 5%	DM15	
	C22, C23	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C24	FACTORY SELECT		
	C25, C26	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C27, C28	Capacitor, Tantalum Electrolytic 22 mfd, 15 V, 10%	CS13	
	C29, C30	Capacitor, Tantalum Electrolytic 22 mfd, 15 V, 10%	CS13	
	C31, C32	Capacitor, Tantalum Electrolytic 22 mfd, 15 V, 10%	CS13	
	C33-C36	Capacitor, Tantalum Electrolytic 2.2 mfd, 15 V, 10%	CS13	

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C37-C39	Capacitor, Tantalum Electrolytic 22 mfd, 15 V, 10%	CS13	
	C40	Capacitor, Polycarbonate .22 mfd, 100 V, 5%	B32541	Siemens
	C41	Capacitor, Polystyrene 560 pf, 63 V, 1%	611	M.I.A.L.
	C42	Capacitor, Tantalum Electrolytic 2.2 mfd, 15 V, 10%	CS13	
	C43-C45	Capacitor, Ceramic Disc .01 mfd		
	C46, C47	Capacitor, Ceramic Disc 10 pf		
	C48	Capacitor, Ceramic Disc 20 pf		
	C49	Capacitor, Ceramic Disc .01 mfd, 50 V		
	C50-C81	Capacitor, Ceramic Disc .01 mfd, 50 V		
	D1	Diode, Silicon	1N3064	
	D2	NOT USED		
	D3	Diode, Silicon	1N3064	
	FC1, FC2A	Connector, 18 Pin	583773-8	Amp, Inc.
	FC2B	Connector, 6 Pin	583773-3	Amp, Inc.
	IC1	Integrated Circuit, Op/Amp	MC1741SCP1	Motorola
	IC2-IC16	Integrated Circuit, Dual Op/Amp	RC4558P	T.I.
	IC17	Integrated Circuit, Digital	CD4069BFX	RCA
	IC18	Integrated Circuit, Digital	CD4023BFX	RCA

TABle 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	IC19	Integrated Circuit, Digital, CMOS	CD4001BFX	RCA
	IC20	Integrated Circuit, Digital, CMOS	CD4013BFX	RCA
	IC21	Integrated Circuit, Digital, CMOS	CD4070BFX	RCA
	IC22	Integrated Circuit, Digital, CMOS	CD4001BFX	RCA
	IC23	Integrated Circuit, Digital, CMOS	CD4013BFX	RCA
	IC24	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC25-IC28	Integrated Circuit, Digital, CMOS	CD4510BFX	RCA
	IC29-IC31	Integrated Circuit, Digital, CMOS	CD4511BFX	RCA
	IC32	Integrated Circuit, Digital, CMOS	CD4002BFX	RCA
	IC33	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC34	Integrated Circuit, Digital, CMOS	CD4013BFX	RCA
	IC35	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC36	Integrated Circuit, Digital, CMOS	CD4069BFX	RCA
	Q1	Transistor, FET	2N5639	
	Q2	Transistor, Silicon	2N4403	
	Q3, Q4	Transistor, FET	2N5639	
	Q5, Q6	Transistor, Silicon	2N4401	
	Q7-Q9	Transistor, Silicon	2N4403	
	Q10-Q13	Transistor, FET	2N5639	
	Q14	Transistor, Silicon	2N4401	
	Q15	Transistor, Silicon	2N4403	
	Q16	Transistor, Silicon	2N4401	

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	Q17	Transistor, Silicon	2N4403	
	Q18-Q20	NOT USED		
	Q21	Transistor, Silicon	2N4401	
	Q22	Transistor, FET	2N5639	
	Q23	Transistor, Silicon	2N4401	

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R1	Resistor, Fixed 39.2 kΩ, 1%	RN55D	A-B
	R2	Resistor, Fixed 6.04 kΩ, 1%	RN55D	A-B
	R3	Resistor, Fixed 383 Ω, 1%	RN55D	A-B
	R4	Resistor, Variable 200 Ω, 10%	72PMR	Beckman
	R5	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R6	Resistor, Fixed 200 Ω, 1%	RN55D	A-B
	R7-R9	Resistor, Fixed 4.99 kΩ, 1%	RN55D	A-B
	R10, R11	Resistor, Fixed 7.87 kΩ, 1%	RN55D	A-B
	R12	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R13-R15	Resistor, Fixed 32.4 kΩ, 1%	RN55D	A-B
	R16, R17	Resistor, Fixed 7.50 kΩ, 1%	RN55D	A-B
	R18	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R19	Resistor, Variable 5 kΩ, 10%	72PMR	Beckman
	R20	Resistor, Fixed 5.49 kΩ, 1%	RN55D	A-B
	R21	Resistor, Fixed 9.53 kΩ, 1%	RN55D	A-B
	R22	Resistor, Fixed 6.04 kΩ, 1%	RN55D	A-B
	R23	Resistor, Variable 1 kΩ, 10%	89PMR	Beckman
	R24	Resistor, Fixed 2.87 kΩ, 1%	RN55D	A-B
	R25	Resistor, Fixed 15.8 kΩ, 1%	RN55D	A-B
	R26	Resistor, Fixed 118 kΩ, 1%	RN55D	A-B
	R27	Resistor, Fixed 14.7 kΩ, 1%	RN55D	A-B
	R28	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R29	Resistor, Fixed 11.5 kΩ, 1%	RN55D	A-B
	R30	Resistor, Fixed 4.87 kΩ, 1%	RN55D	A-B

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R31	Resistor, Fixed 2.87 kΩ, 1%	RN55D	A-B
	R32	Resistor, Fixed 5.11 kΩ, 1%	RN55D	A-B
	R33	Resistor, Fixed 13.7 kΩ, 1%	RN55D	A-B
	R34	Resistor, Fixed 5.36 kΩ, 1%	RN55D	A-B
	R35	Resistor, Variable 1 kΩ, 10%	89PMR	Beckman
	R36	Resistor, Fixed 3.65 kΩ, 1%	RN55D	A-B
	R37	Resistor, Fixed 15.8 kΩ, 1%	RN55D	A-B
	R38	Resistor, Fixed 8.66 kΩ, 1%	RN55D	A-B
	R39	Resistor, Fixed 14.7 kΩ, 1%	RN55D	A-B
	R40	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R41	Resistor, Fixed 2.15 kΩ, 1%	RN55D	A-B
	R42	Resistor, Fixed 11.3 kΩ, 1%	RN55D	A-B
	R43	Resistor, Fixed 5.36 kΩ, 1%	RN55D	A-B
	R44	Resistor, Variable 1 kΩ, 10%	89PMR	Beckman
	R45	Resistor, Fixed 3.65 kΩ, 1%	RN55D	A-B
	R46	Resistor, Fixed 15.8 kΩ, 1%	RN55D	A-B
	R47	Resistor, Fixed 8.66 kΩ, 1%	RN55D	A-B
	R48	Resistor, Fixed 14.7 kΩ, 1%	RN55D	A-B
	R49	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R50	Resistor, Fixed 6.81 kΩ, 1%	RN55D	A-B
	R51	Resistor, Fixed 8.45 kΩ, 1%	RN55D	A-B
	R52	Resistor, Fixed 5.76 kΩ, 1%	RN55D	A-B
	R53	Resistor, Fixed 15.8 kΩ, 1%	RN55D	A-B
	R54	Resistor, Fixed 1.37 kΩ, 1%	RN55D	A-B

TABLE 5-2

HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R55	Resistor, Variable 1 kΩ, 10%	89PMR	Beckman
	R56	Resistor, Fixed 3.24 kΩ, 1%	RN55D	A-B
	R57	Resistor, Fixed 24.3 kΩ, 1%	RN55D	A-B
	R58	Resistor, Fixed 14.7 kΩ, 1%	RN55D	A-B
	R59	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R60	Resistor, Variable 5 kΩ, 10%	72PMR	Beckman
	R61	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R62	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R63, R64	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R65	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R66	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R67	NOT USED		
	R68	Resistor, Fixed 88.7 kΩ, 1%	RN55D	A-B
	R69	Resistor, Variable 10 kΩ, 10%	72PMR	Beckman
	R70	Resistor, Fixed 17.8 kΩ, 1%	RN55D	A-B
	R71	Resistor, Variable 5 kΩ, 10%	72PMR	Beckman
	R72	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R73	Resistor, Fixed 95.3 kΩ, 1%	RN55D	A-B
	R74	Resistor, Variable 10 kΩ, 10%	72PMR	Beckman
	R75	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R76	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R77	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R78	Resistor, Fixed 95.3 kΩ, 1%	RN55D	A-B
	R79	Resistor, Variable 10 kΩ, 10%	72PMR	Beckman

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R80	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R81, R82	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R83	Resistor, Fixed 95.3 kΩ, 1%	RN55D	A-B
	R84	Resistor, Variable 10 kΩ, 10%	72PMR	Beckman
	R85	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R86	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R87-R90	Resistor , Fixed 10 kΩ, 1%	RN55D	A-B
	R91-R94	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R95	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R96	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R97-R100	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R101	Resistor, Fixed 17.8 kΩ, 1%	RN55D	A-B
	R102	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R103	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R104, R105	Resistor, Fixed 30 kΩ, 5%	RCR07	A-B
	R106	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R107	Resistor, Fixed 30 kΩ, 5%	RCR07	A-B
	R108	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R109	Resistor, Fixed 3.83 kΩ, 1%	RN55D	A-B
	R110, R111	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R112	Resistor, Fixed 3.83 kΩ, 1%	RN55D	A-B
	R113	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R114, R115	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R116	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R117	Resistor, Fixed 3.83 kΩ, 1%	RN55D	A-B
	R118	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R119, R120	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R121	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R122, R123	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R124	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R125	Resistor, Fixed 232 kΩ, 1%	RN55D	A-B
	R126	Resistor, Variable 50 kΩ, 10%	72PMR	Beckman
	R127	Resistor, Fixed 301 Ω, 1%	RN55D	A-B
	R128	Resistor, Fixed 150 kΩ, 1%	RN55D	A-B
	R129	Resistor, Variable 100 kΩ, 10%	72PMR	Beckman
	R130	Resistor, Fixed 5.11 kΩ, 1%	RN55D	A-B
	R131	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R132	Resistor, Fixed 20 kΩ, 1%	RN55D	A-B
	R133	Resistor, Fixed 12.4 kΩ, 1%	RN55D	A-B
	R134	Resistor, Fixed 30.1 kΩ, 1%	RN55D	A-B
	R135	Resistor, Variable 100 kΩ, 10%	72PMR	Beckman
	R136	Resistor, Fixed 301 Ω, 1%	RN55D	A-B
	R137	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R138	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R139	Resistor, Fixed 7.15 kΩ, 1%	RN55D	A-B
	R140	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R141	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R142	Resistor, Fixed 3.01 kΩ, 1%	RN55D	A-B

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R143	Resistor, Fixed 137 kΩ, 1%	RN55D	A-B
	R144	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R145	Resistor, Fixed 34.8 kΩ, 1%	RN55D	A-B
	R146	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R147	Resistor, Fixed 1 kΩ, 1%	RN55D	A-B
	R148	Resistor, Fixed 511 kΩ, 1%	RN55D	A-B
	R149-R151	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R152	Resistor, Fixed 51 kΩ, 5%	RCR07	A-B
	R153, R154	NOT USED		
	R155-R175	Resistor, Fixed 270 Ω, 5%	RCR07	A-B
	R176	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R177	Resistor, Fixed 100 Ω, 5%	RCR07	A-B
	R178	Resistor, Fixed 10 Ω, 5%	RCR07	A-B
	R179-R181	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R182	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R183	Resistor, Fixed 13.7 kΩ, 1%	RN55D	A-B
	R184	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R185	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R186	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R187	Resistor, Fixed 270 Ω, 5%	RCR07	A-B
	R188	Resistor, Fixed 130 Ω, 5%	RCR07	A-B
	R189, R190	Resistor, Fixed 20 kΩ, 1%	RN55D	A-B
	R191, R192	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B

TABLE 5-2 HLI 41-01-100 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	T1	Transformer	TM-3186	HLI
	TS1	Transformer Shield	HU-2440-906	Hudson

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C1	Capacitor, Ceramic Disc .1 mfd, 20 V	UK-20-104	Centralab
	C2	Capacitor, Polystyrene .047 mfd, 63 V, 1%	611	M.I.A.L.
	C3	NOT USED		
	C4	Capacitor, Dipped Mica 33 pf, 500 V, 5%	DM15	
	C5	Capacitor, Dipped Mica 110 pf, 500 V, 5%	DM15	
	C6	Capacitor, Trimmer 5.5-18 pf		
	C7, C8	Capacitor, Dipped Mica 390 pf, 500 V, 5%	DM15	
	C9-C11	Capacitor, Ceramic Disc 47 pf, 1 kV, 10%		
	C12	Capacitor, Ceramic Disc .01 mfd, 50 V, 20%		
	C13	Capacitor, Polystyrene 1000 pf, 63 V, 1%	611	M.I.A.L.
	C14-C17	Capacitor, Polystyrene .01 mfd, 63 V, 1%	611	M.I.A.L.
	C18	Capacitor, Dipped Mica 68 pf, 500 V, 5%	DM15	
	C19	Capacitor, Dipped Mica 18 pf, 500 V, 5%	DM15	
	C20	Capacitor, Polycarbonate .47 mfd, 100 V, 5%	B32541	Siemens
	C21	Capacitor, Polystyrene .022 mfd, 63 V, 1%	611	M.I.A.L.
	C22	Capacitor, Polycarbonate .1 mfd, 250 V, 5%	B32541	Siemens
	C23	Capacitor, Ceramic Disc .01 mfd, 50 V 20%		
	C24	Capacitor, Dipped Mica 100 pf, 500 V, 5%	DM15	
	C25	Capacitor, Polycarbonate .47 mfd, 100 V, 5%	B32541	Siemens
	C26	Capacitor, Polystyrene 4700 pf, 63 V, 1%	611	M.I.A.L.
	C27	Capacitor, Polystyrene .012 mfd, 63 V, 1%	611	M.I.A.L.
	C28	Capacitor, Dipped Mica 680 pf, 500 V, 5%	DM15	
	C29	Capacitor, Ceramic Disc 47 pf, 1 kV, 10%		
	C30	Capacitor, Aluminium Electrolytic 50 mfd, 35 V	TAD	IEC

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C31	Capacitor, Ceramic Disc .1 mfd, 20 V, 10%	UK-20-104	Centralab
	C32	Capacitor, Polycarbonate .47 mfd, 100 V, 5%	B32541	Siemens
	C33, C34	Capacitor, Ceramic Disc .01 mfd, 50 V		
	C35, C36	Capacitor, Tantalum Electrolytic 22 mfd, 15 V	CS13	
	C37	Capacitor, Ceramic Disc .1 mfd, 20 V, 10%	UK-20-104	Centralab
	C38	Capacitor, Aluminium Electrolytic 2100 mfd, 40 V	39D	Sprague
	C39	Capacitor, Tantalum Electrolytic 2.2 mfd, 15 V, 10%	CS13	
	C40	Capacitor, Ceramic Disc .01 mfd, 50 V		
	C41	Capacitor, Ceramic Disc .001 mfd, 1 kV		
	C42	Capacitor, Aluminium Electrolytic 220 mfd, 25 V	B41283	Siemens
	C43	Capacitor, Ceramic Disc .047 mfd, 50 V		
	C44	Capacitor, Aluminium Electrolytic 220 mfd, 25 V	B41283	Siemens
	C45	Capacitor, Ceramic Disc .047 mfd, 50 V		
	C46	Capacitor, Aluminium Electrolytic 220 mfd, 25 V	B41283	Siemens
	C47	Capacitor, Ceramic Disc .047 mfd, 50 V		
	C48	Capacitor, Ceramic Disc 470 pf		
	C49-C70	Capacitor, Ceramic Disc .01 mfd, 50 V		
	D1	Diode, Silicon	1N823A	
	D2-D6	Diode, Silicon	1N3064	
	D7	NOT USED		
	D8-D18	Diode, Silicon	1N3064	
	D19	Diode Bridge	KBP-04	G. I.

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	D20, D21	Diode Silicon	1N3064	
	FC3, FC4	Connector, 18 Pin	583773-8	Amp, Inc.
	IC1	NOT USED		
	IC2	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	IC3	Integrated Circuit, Digital, CMOS	MC14501BALD	Motorola
	IC4, IC5	NOT USED		
	IC6	Integrated Circuit, Digital, CMOS	F4013DCQR	Fairchild
	IC7	Integrated Circuit, Digital, CMOS	F4011DCQR	Fairchild
	IC8, IC9	Integrated Circuit, Digital, CMOS	CD4518BFX	RCA
	IC10, IC11	Integrated Circuit, Digital, CMOS	CD4520BFX	RCA
	IC12	Integrated Circuit, Digital, CMOS	CD4012BFX	RCA
	IC13	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC14	Integrated Circuit, Digital, CMOS	CD4518BFX	RCA
	IC15	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	IC16	Integrated Circuit, Op/Amp	MC1741SCP1	Motorola
	IC17	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC18	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC19	Integrated Circuit, Digital, CMOS	CD4518BFX	RCA
	IC20	Integrated Circuit, Digital, CMOS	CD4013BFX	RCA
	IC21-IC23	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	IC24	Integrated Circuit, Digital, LSI	MK5005N	Mostek
	IC25	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	IC26	Integrated Circuit, Digital, CMOS	CD4046BFX	RCA
	IC27, IC28	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	IC29	Integrated Circuit, Digital, CMOS	CD4011BFX	RCA
	IC30	Integrated Circuit, Digital, CMOS	CD4510BFX	RCA
	IC31	Integrated Circuit, Digital, CMOS	CD4013BFX	RCA
	IC32	Integrated Circuit, Digital, CMOS	CD4028BFX	RCA
	IC33, IC34	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	IC35-IC37	Integrated Circuit, Digital, CMOS	CD4066BFX	RCA
	IC38	Integrated Circuit, Op/Amp	MC1741SCP1	Motorola
	IC39	Integrated Circuit, Op/Amp	LF356H	National
	IC40	Integrated Circuit, Op/Amp	MC1741SCP1	Motorola
	IC41, IC42	Integrated Circuit, Regulator	CA3085A	RCA
	IC43	Integrated Circuit, Dual, Op/Amp	RC4558P	T. I.
	Q1	Transistor, Silicon	2N4401	
	Q2	Transistor, Silicon	2N4402	
	Q3	Transistor, Silicon	2N2484	
	Q4	Transistor, Silicon	2N4403	
	Q5	Transistor, Silicon	2N4401	
	Q6	Transistor, Silicon	MPS-A18	Motorola

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	Q7	Transistor, Silicon	2N2369	
	Q8-Q10	Transistor, Silicon	2N4401	
	Q11-Q14	Transistor, Silicon	MPS-A14	Motorola
	Q15-Q20	Transistor, Silicon	2N4401	
	Q21	Transistor, Silicon	2N5980	
	Q22	Transistor, Silicon	MJE-1100	Motorola
	Q23	Transistor, Silicon	MJE-1090	Motorola
	Q24	Transistor, Silicon	2N5983	
	Q25	Transistor, Silicon	2N4401	
	R1, R2	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R3	NOT USED		
	R4	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R5	Resistor, Fixed 562 Ω, 1%	RN55D	A-B
	R6	Resistor, Fixed 182 kΩ, 1%	RN55D	A-B
	R7	NOT USED		
	R8	Resistor, Fixed 36 kΩ, 5%	RCR07	A-B
	R9	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R10	Resistor, Variable 20 kΩ, 10%	72PMR	Beckman
	R11	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R12	Resistor, Fixed 357 Ω, 1%	RN55D	A-B
	R13	Resistor, Fixed 374 Ω, 1%	RN55D	A-B
	R14	Resistor, Fixed 121 kΩ, 1%	RN55D	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R15	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R16	Resistor, Fixed 2.37 kΩ, 1%	RN55D	A-B
	R17	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R18	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R19	Resistor, Fixed 24 kΩ, 5%	RCR07	A-B
	R20	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R21	Resistor, Fixed 5.1 kΩ, 5%	RCR07	A-B
	R22	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R23	Resistor, Fixed 51 kΩ, 5%	RCR07	A-B
	R24	NOT USED		
	R25	Resistor, Fixed 10 MΩ, 5%	RCR07	A-B
	R26	Resistor, Fixed 2 kΩ, 5%	RCR07	A-B
	R27	Resistor, Fixed 6.2 kΩ, 5%	RCR07	A-B
	R28	Resistor, Fixed 160 kΩ, 5%	RCR07	A-B
	R29	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R30	Resistor, Fixed 12 kΩ, 5%	RCR07	A-B
	R31	Resistor, Fixed 68 kΩ, 5%	RCR07	A-B
	R32	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R33	Resistor, Fixed 68 kΩ, 5%	RCR07	A-B
	R34, R35	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R36, R37	Resistor, Fixed 68 kΩ, 5%	RCR07	A-B
	R38	NOT USED		
	R39	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R40	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R41	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R42	Resistor, Fixed 510 Ω, 5%	RCR07	A-B
	R43	Resistor, Fixed 12 kΩ, 5%	RCR07	A-B
	R44	Resistor, Fixed 1.5 kΩ, 5%	RCR07	A-B
	R45	Resistor, Fixed 215 kΩ, 1%	RN55D	A-B
	R46	Resistor, Fixed 825 Ω, 1%	RN55D	A-B
	R47	Resistor, Fixed 309 kΩ, 1%	RN55D	A-B
	R48	Resistor, Variable 50 kΩ, 10%	72PMR	Beckman
	R49	Resistor, Fixed 6.19 kΩ, 1%	RN55D	A-B
	R50	Resistor, Fixed 825 Ω, 1%	RN55D	A-B
	R51	Resistor, Fixed 309 kΩ, 1%	RN55D	A-B
	R52, R53	Resistor, Variable 50 kΩ, 10%	72PMR	Beckman
	R54	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R55	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R56	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R57	Resistor, Fixed 20 kΩ, 1%	RN55D	A-B
	R58	Resistor, Fixed 47 kΩ, 5%	RCR07	A-B
	R59	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R60	Resistor, Fixed 33.2 kΩ, 1%	RN55D	A-B
	R61, R62	Resistor, Fixed 2.4 MΩ, 5%	RCR07	A-B
	R63	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R64, R65	Resistor, Fixed 100 kΩ, 1%	RN55D	A-B
	R66	Resistor, Fixed 20.0 kΩ, 1%	RN55D	A-B
	R67	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R68	Resistor, Fixed 1 MΩ, 1%	RN55D	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R69	Resistor, Variable 10 kΩ, 10%	72PMR	Beckman
	R70	Resistor, Fixed 1 kΩ, 1%	RN55D	A-B
	R71	Resistor, Fixed 634 kΩ, 1%	RN55D	A-B
	R72	Resistor, Fixed 213.9 kΩ, .1%	RN55C	ACI
	R73	Resistor, Fixed 130.4 kΩ, .1%	RN55C	ACI
	R74	Resistor, Fixed 95.44 kΩ, .1%	RN55C	ACI
	R75	Resistor, Fixed 76.74 kΩ, .1%	RN55C	ACI
	R76	Resistor, Fixed 65.50 kΩ, .1%	RN55C	ACI
	R77	Resistor, Fixed 58.39 kΩ, .1%	RN55C	ACI
	R78	Resistor, Fixed 53.87 kΩ, .1%	RN55C	ACI
	R79	Resistor, Fixed 51.17 kΩ, .1%	RN55C	ACI
	R80	Resistor, Fixed 49.90 kΩ, .1%	RN55C	ACI
	R81	Resistor, Variable 20 kΩ, 10%	72PMR	Beckman
	R82	Resistor, Fixed 300 kΩ, 5%	RCR07	A-B
	R83	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R84	Resistor, Fixed 300 kΩ, 5%	RCR07	A-B
	R85	Resistor, Variable 100 kΩ, 10%	72PMR	Beckman
	R86	Resistor, Fixed 1 MΩ, 1%	RN55D	A-B
	R87	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R88	Resistor, Fixed 6.04 kΩ, 1%	RN55D	A-B
	R89, R90	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R91	Resistor, Fixed 9.53 kΩ, 1%	RN55D	A-B
	R92	Resistor, Variable 1 kΩ, 10%	72PMR	Beckman
	R93	Resistor, Fixed 133 kΩ, 1%	RN55D	A-B
	R94	Resistor, Fixed 36.5 kΩ, 1%	RN55D	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R95	Resistor, Fixed 7.50 kΩ, 1%	RN55D	A-B
	R96	Resistor, Fixed 1.50 kΩ, 1%	RN55D	A-B
	R97	Resistor, Fixed 133 kΩ, 1%	RN55D	A-B
	R98	Resistor, Fixed 36.5 kΩ, 1%	RN55D	A-B
	R99	Resistor, Fixed 7.50 kΩ, 1%	RN55D	A-B
	R100	Resistor, Fixed 1.50 kΩ, 1%	RN55D	A-B
	R101	Resistor, Fixed 133 kΩ, 1%	RN55D	A-B
	R102	Resistor, Fixed 36.5 kΩ, 1%	RN55D	A-B
	R103	Resistor, Fixed 7.50 kΩ, 1%	RN55D	A-B
	R104	Resistor, Fixed 1.50 kΩ, 1%	RN55D	A-B
	R105	Resistor, Fixed 25.5 kΩ, 1%	RN55D	A-B
	R106	Resistor, Fixed 137 Ω, 1%	RN55D	A-B
	R107	Resistor, Fixed 316 kΩ, 1%	RN55D	A-B
	R108	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R109	Resistor, Fixed 10.2 kΩ, 1%	RN55D	A-B
	R110	Resistor, Fixed 340 Ω, 1%	RN55D	A-B
	R111	Resistor, Fixed 357 kΩ, 1%	RN55D	A-B
	R112	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R113	Resistor, Fixed 2.87 kΩ, 1%	RN55D	A-B
	R114	Resistor, Fixed 562 Ω, 1%	RN55D	A-B
	R115	Resistor, Fixed 357 kΩ, 1%	RN55D	A-B
	R116	Resistor, Fixed 1 MΩ, 5%	RCR07	A-B
	R117, R118	NOT USED		
	R119	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R120	Resistor, Fixed 20 kΩ, 1%	RN55D	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R121	NOT USED		
	R122, R123	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R124-R127	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R128-R134	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R135-R141	Resistor, Fixed 68 Ω, 5%	RCR07	A-B
	R142	Resistor, Fixed 4.7 kΩ, 5%	RCR07	A-B
	R143	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R144	Resistor, Fixed 10 kΩ, 5%	RCR07	A-B
	R145, R146	Resistor, Fixed 12 kΩ, 5%	RCR07	A-B
	R147, R148	Resistor, Fixed 68 Ω, 5%	RCR07	A-B
	R149	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B
	R150	Resistor, Fixed 1 kΩ, 10%	RN55D	A-B
	R151	Resistor, Fixed 75 Ω, 1%	RN55D	A-B
	R152	Resistor, Variable 1 kΩ, 10%	72PMR	Beckman
	R153	Resistor, Fixed 10.0 kΩ, 1%	RN55D	A-B
	R154	Resistor, Fixed 536 Ω, 1%	RN55D	A-B
	R155	Resistor, Fixed 10.0 kΩ, 1%	RN55D	A-B
	R156	Resistor, Fixed 8.2 Ω, 5%	RCR07	A-B
	R157	Resistor, Fixed 1 kΩ, 1%	RN55D	A-B
	R158	Resistor, Fixed .56 Ω, 2 W, 5%	RCR42	A-B
	R159	Resistor, Fixed 10.1 kΩ, 1%	RN55D	A-B
	R160	Resistor, Variable 1 kΩ, 10%	72PMR	Beckman
	R161	Resistor, Fixed 5.11 kΩ, 1%	RN55D	A-B
	R162	Resistor, Fixed 100 kΩ, 5%	RCR07	A-B

TABLE 5-3 HLI 41-01-200 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R163	Resistor, Fixed 240 kΩ, 5%	RCR07	A-B
	R164, R165	Resistor, Fixed 10.1 kΩ, 1%	RN55D	A-B
	R166	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R167	Resistor, Fixed 39 kΩ, 5%	RCR07	A-B
	R168	Resistor, Fixed 20 kΩ, 5%	RCR07	A-B
	R169	Resistor, Fixed 39 kΩ, 5%	RCR07	A-B
	SO1	Integrated Circuit, Socket	C931602	T. I.
	T1	Transformer	TM-3188	HLI
	Y1	Crystal, 2 MHz		

TABLE 5-4 HLI 41-01-300 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	DS1	LED Display	4630	Monsanto
	DS2-DS8	LED Display	4640	Monsanto
	FC1	Flat Cable, 24 Conductor, 6"	2-86947-3	Amp, Inc.
	FC2	Flat Cable, 18 Conductor, 6"	1-86947-3	Amp, Inc.
	R1	Resistor, Fixed 26 Ω, 5%	RCR07	A-B
	SO1-SO8	Integrated Circuit, Socket	C931402	T. I.

TABLE 5-5 HLI 41-01-400 BOARD PARTS LIST

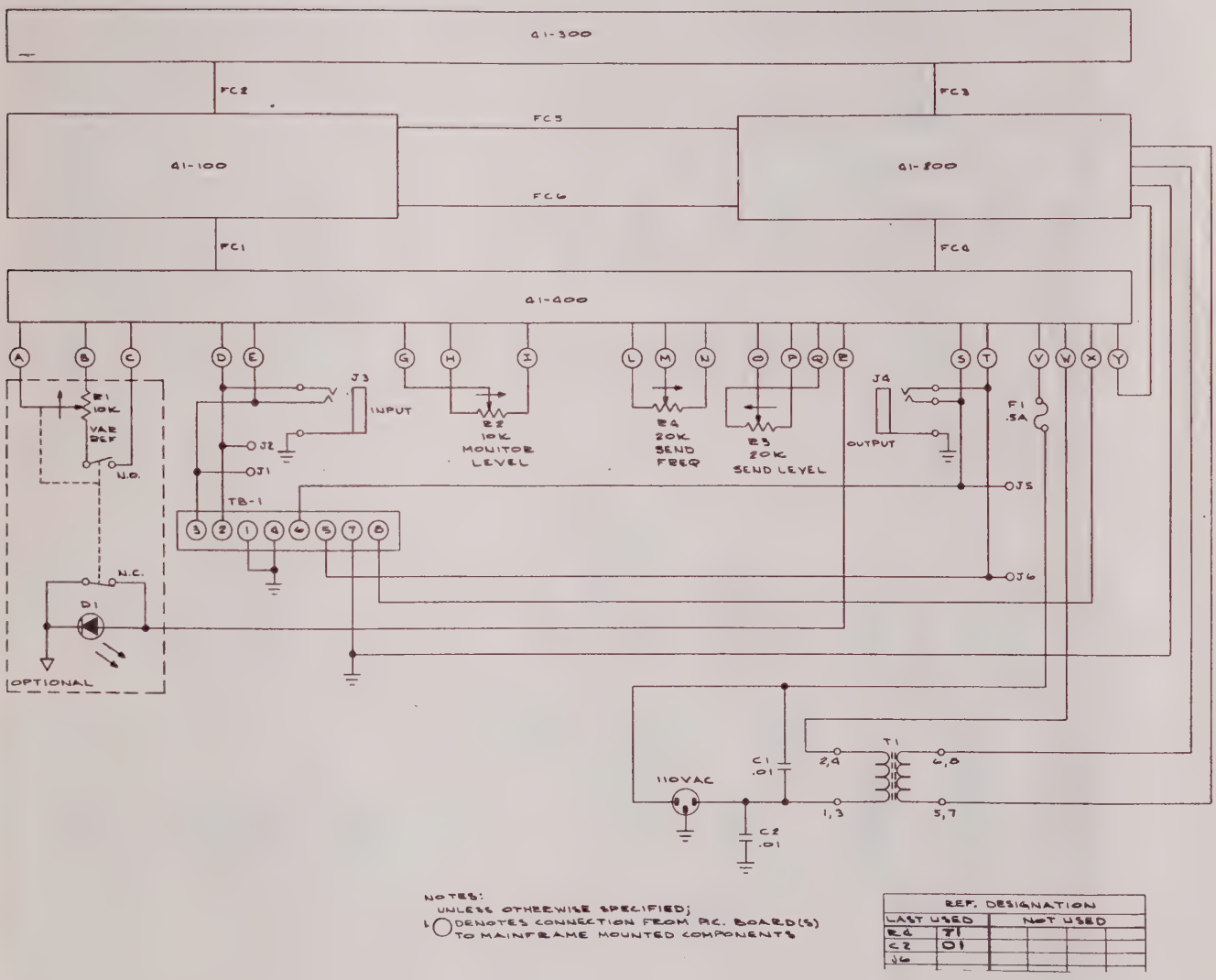
Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C1, C2	Capacitor, Aluminium Electrolytic 75 mfd, 100 V	39D	Sprague
	C3	Capacitor, Tantalum Electrolytic 2.2 mfd, 15 V, 10%	CS13	
	C4, C5	Capacitor, Aluminium Electrolytic 50 mfd, 35 V	TAD	IEC
	C6, C7	NOT USED		
	C8, C9	Capacitor, Aluminium Electrolytic 75 mfd, 100 V	39D	Sprague
	C10, C11	Capacitor, Ceramic Disc .01 mfd, 50 V		
	FC1, FC2	Flat Cable, 18 Conductor, 4"	1-86945-7	Amp, Inc.
	IC1	Integrated Circuit, Dual Op/Amp	RC4558P	T. I.
	Q1	Transistor, Silicon	2N4401	
	Q2	Transistor, Silicon	2N4403	
	R1	Resistor, Fixed 5.36 kΩ, 1%	RN55D	A-B
	R2	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B
	R3	Resistor, Fixed 9.09 kΩ, 1%	RN55D	A-B
	R4	Resistor, Variable 2 kΩ, 10%	72PMR	Beckman
	R5	OPTIONAL, Resistor, Fixed 4.75 kΩ, 1%	RN55D	A-B
	R6	Resistor, Fixed 10 kΩ, 1%	RN55D	A-B

TABLE 5-5 HLI 41-01-400 BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R7	OPTIONAL, Resistor, Fixed 680 Ω, 5%	RCR07	A-B
	R8	Resistor, Fixed 3.24 kΩ, 1%	RN55D	A-B
	R9	Resistor, Fixed 23.7 kΩ, 1%	RN55D	A-B
	R10	Resistor, Fixed 619 Ω, 3 W, 1%	RS135X	RCD
	R11	Resistor, Fixed 931 Ω, 3 W, 1%	RS135X	RCD
	R12	Resistor, Fixed 51 Ω, 5%	RCR07	A-B
	R13	Resistor, Fixed 51 kΩ, 5%	RCR07	A-B
	R14, R15	Resistor, Fixed 130 Ω,5%	RCR07	A-B
	R16	Resistor, Fixed 3.01 kΩ, 1%	RN55D	A-B
	R17	Resistor, Fixed 30.9 Ω, 1%	RN55D	A-B
	R18	Resistor, Fixed 3.16 kΩ, 1%	RN55D	A-B
	R19, R20	Resistor, Fixed 348 Ω, 1%	RN55D	A-B
	R21	Resistor, Fixed 165 Ω, 1%	RN55D	A-B
	S1-S10	Switch	TS1 760 601-N2	Schadow
	S11-S20	Switch	TS1 760 601-N1	Schadow
	SPKR1	Transducer	D655-B-200	Dyna Magnetics Devices

TABLE 5-6 HLI 41-01 MAINFRAME PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	C1, C2	Capacitor, Ceramic Disc .10, 1.6 kV		
	F1	Fuse, Slo-Blo .5 A, 125 V	3AG	Littlefuse
	HS1	Heat Sink	A41-4	HLI
	J1, J2	Binding Post, Red	DF-21-RC	Superior
	J3, J4	Jack, 310	12B	Switchcraft
	J5, J6	Binding Post, Red	DF-21-RC	Superior
	R1	NOT USED		
	R2	Resistor, Variable 10 kΩ	WA2G032P 103DA	A-B
	R3, R4	Resistor, Variable 20 kΩ, 10 Turn	7286-115-0	Beckman
	T1	Transformer, Power	DPC-40-600	Signal Transformer
	TB1	Barrier Strip	8-140Y	Cinch-Jones



NOTES:
UNLESS OTHERWISE SPECIFIED;
1. ○ DENOTES CONNECTION FROM P.C. BOARD(S) TO MAINFRAME MOUNTED COMPONENTS

REF. DESIGNATION		
LAST USED		NOT USED
R4	T1	
C2	D1	
J6		

FIGURE 5-3 MAINFRAME INTERCONNECT DIAGRAM

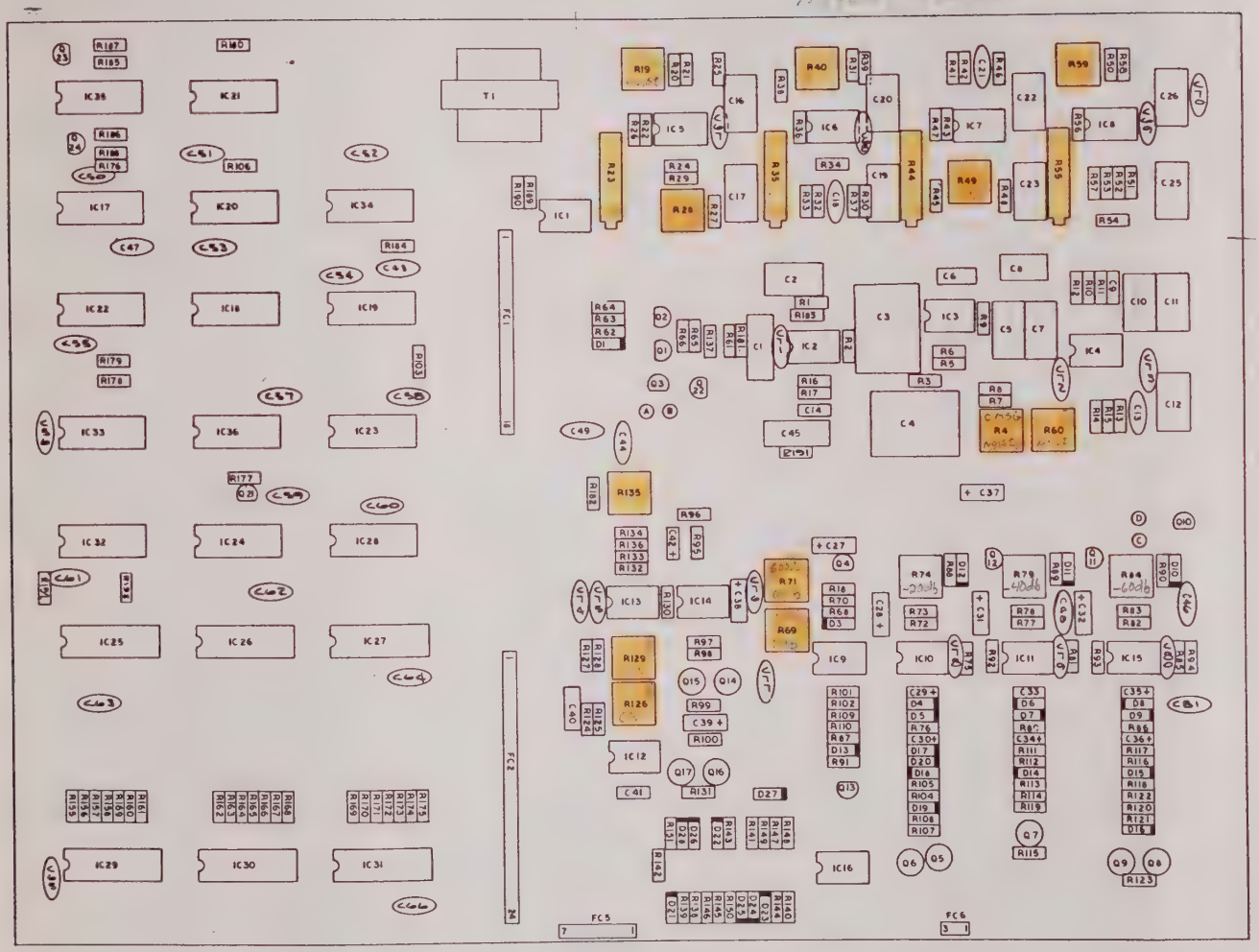


FIGURE 5-4 41-100 COMPONENT LAYOUT

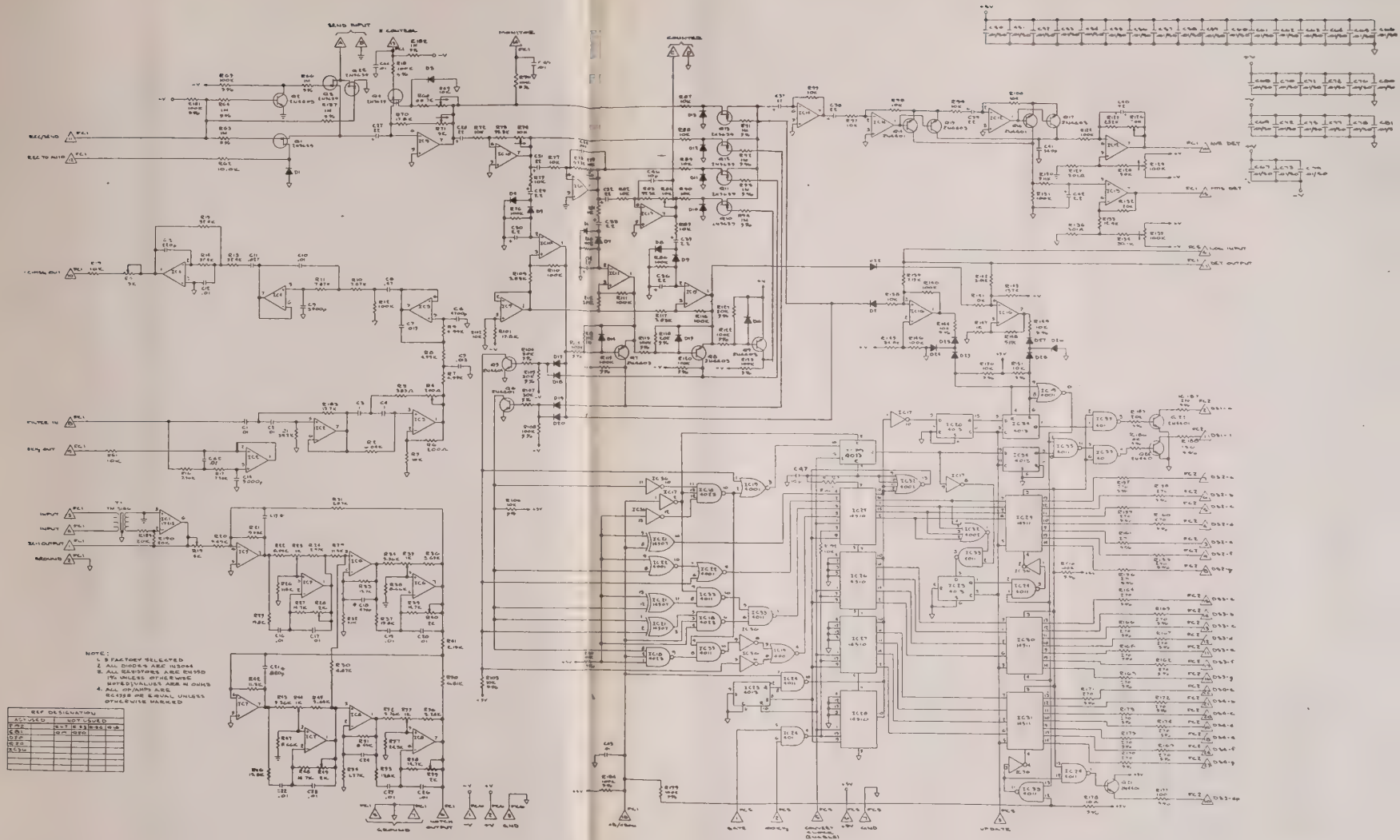


FIGURE 5-5 41-100 SCHEMATIC DIAGRAM

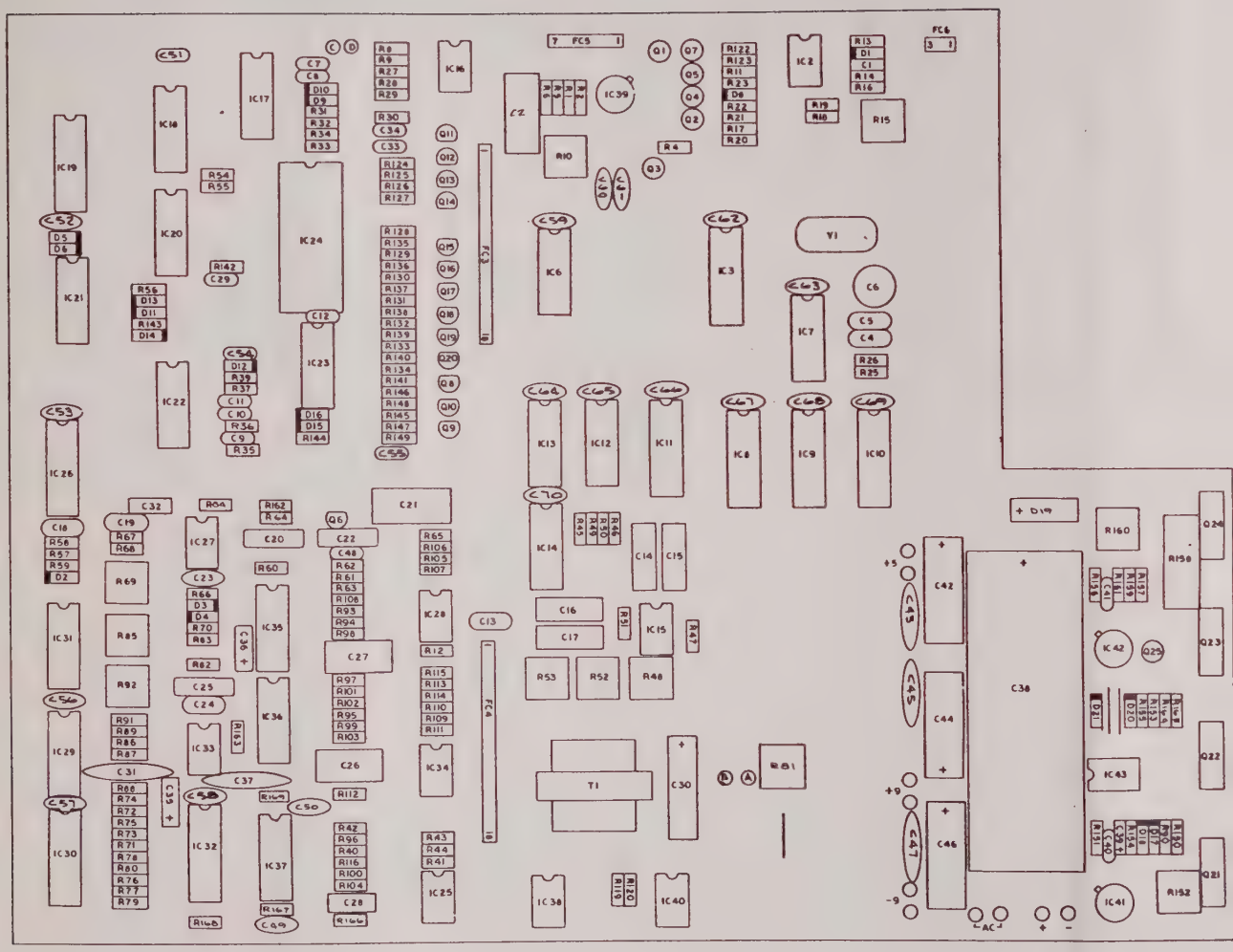


FIGURE 5-6 41-200 COMPONENT LAYOUT

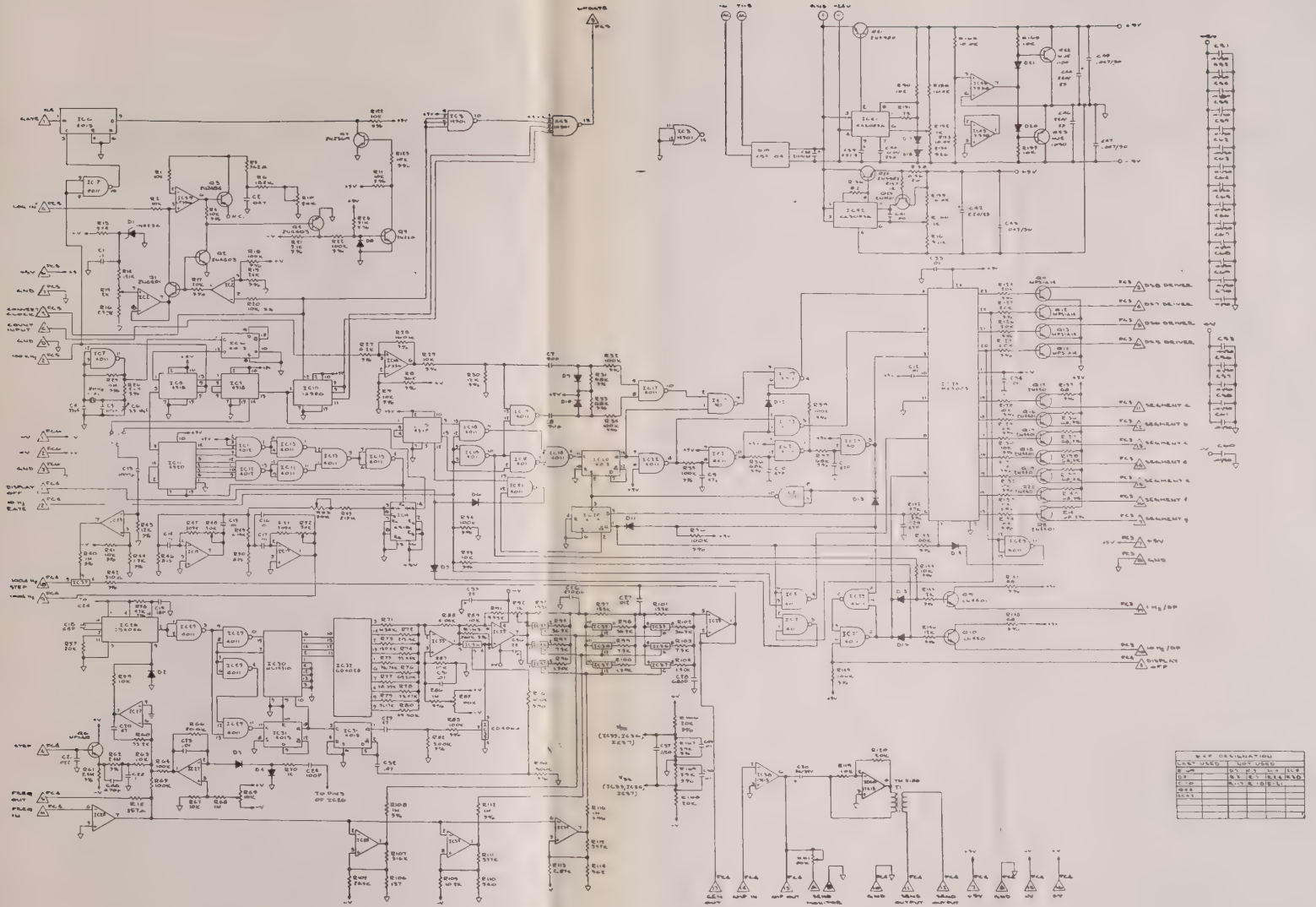


FIGURE 5-7 41-200 SCHEMATIC DIAGRAM

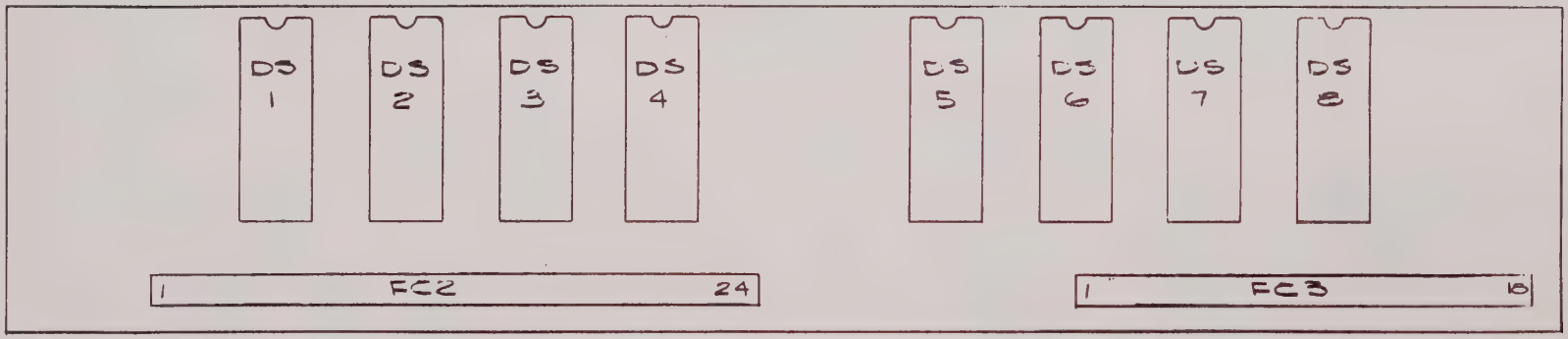


FIGURE 5-8 41-300 COMPONENT LAYOUT

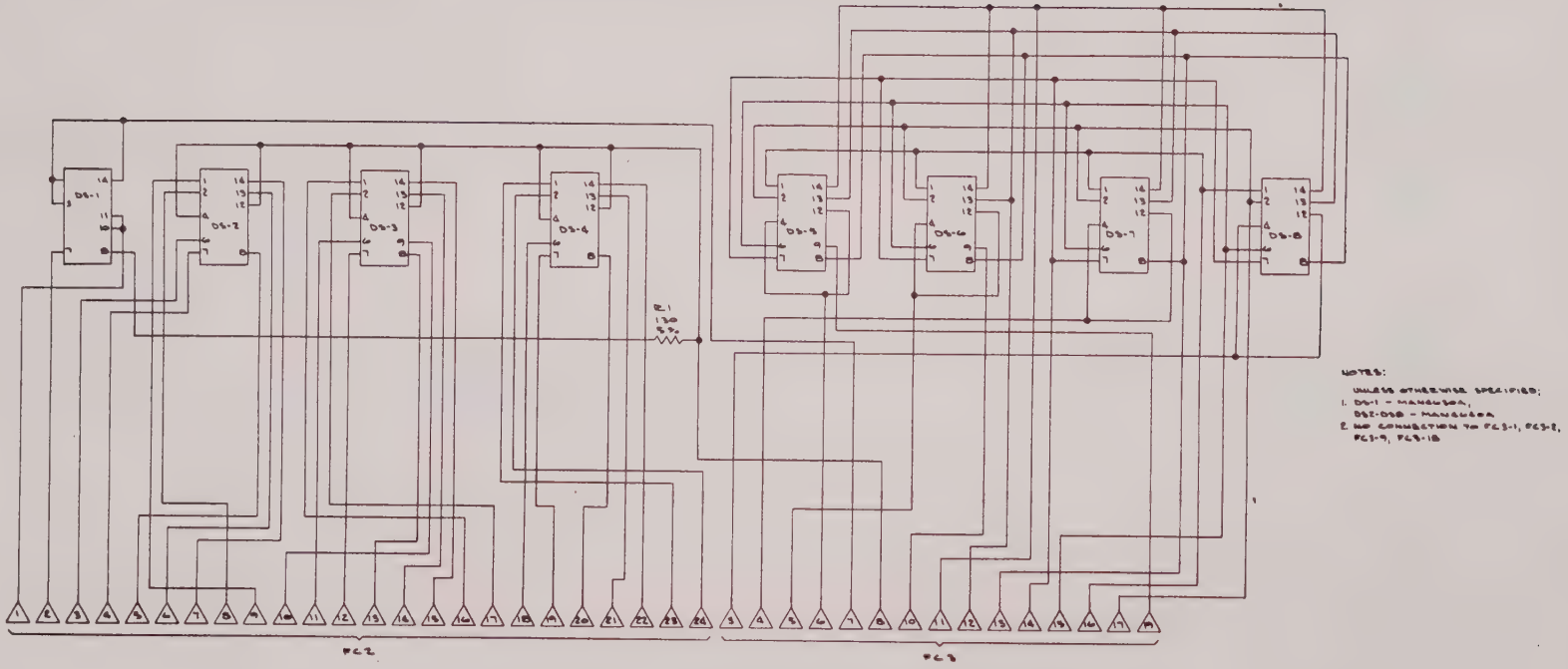
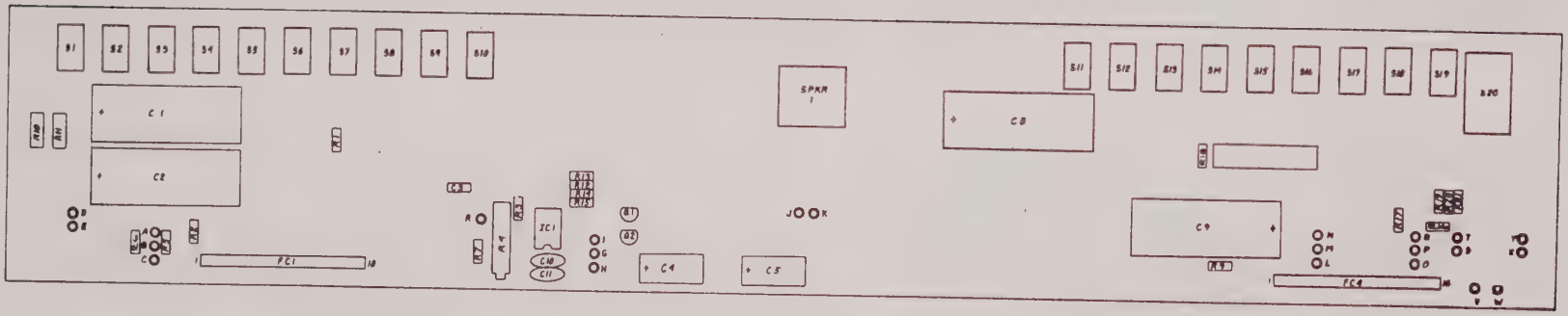


FIGURE 5-9 41-300 SCHEMATIC DIAGRAM


S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
SPKR
C1
C2
C8
C9
C4
C5
C10
C11
IC1
R1
R2
R3
R4
R5
R6
R7
R8
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R10
R11
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R40

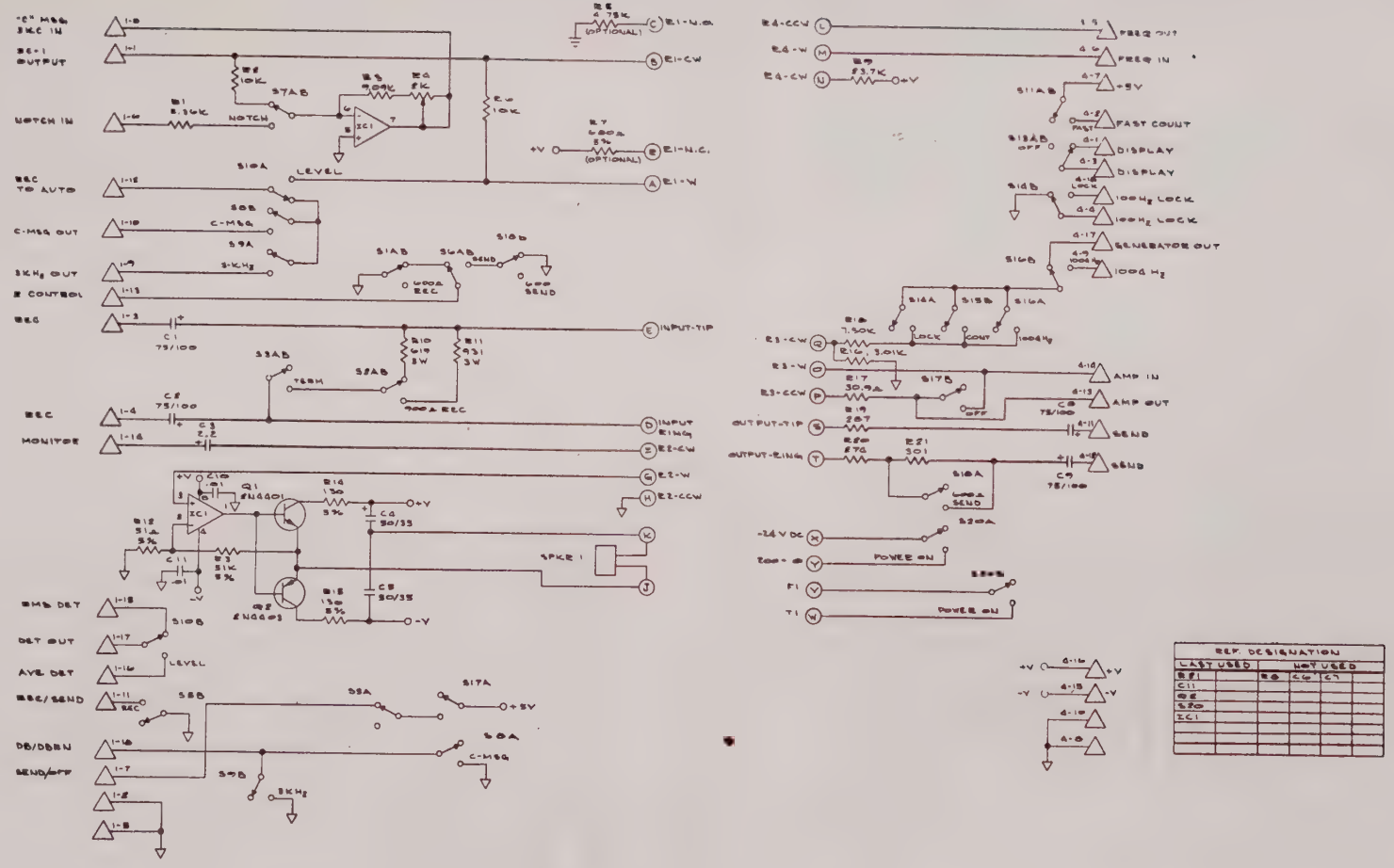

FIGURE 5-11 41-400 SCHEMATIC DIAGRAM

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